Final

Facility-wide Groundwater Monitoring Program
RVAAP-66 Facility-wide Groundwater
Annual Report for 2022

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912QR-21-D-0016
Delivery Order No. W912QR22F0186

Prepared for:

U.S. Army Corps of Engineers
Louisville District

Prepared by:

Leidos
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

May 3, 2023

THIS PAGE INTENTIONALLY LEFT BLANK.

Final

Facility-wide Groundwater Monitoring Program
RVAAP-66 Facility-wide Groundwater
Annual Report for 2022

THIS PAGE INTENTIONALLY LEFT BLANK.

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	03-05-2023
2. REPORT TYPE	Technical
3. DATES COVERED *(From - To)*	Sep 2004- May 2023
4. TITLE AND SUBTITLE	Final Facility-wide Groundwater Monitoring Program Annual Report for 2022 Groundwater Investigation and Reporting Services Ravenna Army Ammunition Plant Restoration Program Portage and Trumbull Counties, Ohio
5a. CONTRACT NUMBER	W912QR-21-D-0016, DO W912QR22F0186
5b. GRANT NUMBER	NA
5c. PROGRAM ELEMENT NUMBER	NA
5d. PROJECT NUMBER	NA
5e. TASK NUMBER	NA
5f. WORK UNIT NUMBER	NA
6. AUTHOR(S)	Polan, Danielle, M.
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	Leidos 8866 Commons Boulevard, Suite 201 Twinsburg, Ohio 44087
8. PERFORMING ORGANIZATION REPORT NUMBER	NA
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	USACE - Louisville District U.S. Army Corps of Engineers 600 Martin Luther King Jr., Place Louisville, Kentucky 40202-2232
10. SPONSOR/MONITOR'S ACRONYM(S)	USACE
11. SPONSOR/MONITOR'S REPORT NUMBER(S)	NA
12. DISTRIBUTION/AVAILABILITY STATEMENT	Reference distribution page.
13. SUPPLEMENTARY NOTES	None.

14. ABSTRACT

This Annual Report summarizes activities conducted in 2022 as part of the Facility-wide Groundwater Monitoring Program (FWGWMP) in support of the Ravenna Army Ammunition Plant Restoration Program. This report provides a description of field activities performed, presents field and analytical results, updates potentiometric surfaces, analyzes chemical data collected to date, and provides conclusions of the 2022 activities and recommendations for the 2023 FWGWMP activities.

15. SUBJECT TERMS

groundwater, monitoring well, statistics, hydraulic gradient, trend lines

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	U	1212	Jay Trumble	502.315.6349

THIS PAGE INTENTIONALLY LEFT BLANK.

PLACEHOLDER FOR:

Documentation of Ohio EPA Concurrence of Final Document

(Documentation to be provided once concurrence is issued.)

THIS PAGE INTENTIONALLY LEFT BLANK.

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Company Name: Leidos

Contract and Delivery Order Number: Contract No. W912QR-21-D-0016, Delivery Order No. W912QR22F0186

Document Name: Facility-wide Groundwater Monitoring Program, Annual Report for 2022, RVAAP-66 Facility-wide Groundwater, Ravenna Army Ammunition Plant Restoration Program, Camp James A. Garfield Joint Military Training Center, Portage and Trumbull Counties, Ohio

Notice is hereby given that an independent technical review, that is appropriate to the level of risk and complexity inherent in the project, has been conducted. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level obtained; and reasonableness of the result, including whether the product meets the customer's needs consistent with law and existing Corps policy. All concerns and comments resulting from these independent technical reviews have been resolved.

Jed Thomas, PMP, PE Project Manager	5/3/2023 Date
Ryan Laurich Independent Technical Review Team Leader	5/3/2023 Date

Significant concerns and explanation of the resolutions are documented within the project file.

As noted above, all concerns resulting from the independent technical review of the document have been fully resolved.

Lisa Jones-Bateman, REM, PMP Senior Program Manager	5/3/2023 Date

THIS PAGE INTENTIONALLY LEFT BLANK.

Final

Facility-wide Groundwater Monitoring Program
RVAAP-66 Facility-wide Groundwater
Annual Report for 2022

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912QR-21-D-0016
Delivery Order No. W912QR22F0186

Prepared for:
U.S. Army Corps of Engineers
600 Martin Luther King, Jr. Place
Louisville, Kentucky 40202

Prepared by:
Leidos
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

May 3, 2023

THIS PAGE INTENTIONALLY LEFT BLANK.

DOCUMENT DISTRIBUTION
for the
Final
Facility-wide Groundwater Monitoring Program
RVAAP-66 Facility-wide Groundwater
Annual Report for 2022
Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Name/Organization	Number of Printed Copies	Number of Electronic Copies
Kevin Palombo, Ohio EPA-NEDO	Electronic submittal via Ohio EPA File Transfer (Powered by LiquidFiles)	
Liam McEvoy, Ohio EPA-NEDO	Email transmittal letter only	
Natalie Oryshkewych, Ohio EPA-NEDO	Email transmittal letter only	
Tom Schneider, Ohio EPA-SWDO	Email transmittal letter only	
Katie Tait, OHARNG, Camp James A. Garfield Kevin Sedlak, ARNG, Camp James A. Garfield	Electronic Version Posted to DOD SAFE	
Steve Kvaal, USACE – Louisville District	Electronic Version Posted to DOD SAFE	
Jay Trumble, USACE – Louisville District	Electronic Version Posted to DOD SAFE	
Administrative Records Manager – Camp James A. Garfield	2	2
Jed Thomas, Leidos	Email transmittal letter only	
Ryan Laurich, Leidos	Email transmittal letter only	

ARNG = Army National Guard
NEDO = Northeast District Office
OHARNG = Ohio Army National Guard
Ohio EPA = Ohio Environmental Protection Agency
SWDO = Southwest District Office
USACE = U.S. Army Corps of Engineers

THIS PAGE INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

amsl	Above Mean Sea Level
AOC	Area of Concern
Army	U.S. Department of the Army
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CJAG	Camp James A. Garfield
DFFO	Director's Final Findings and Orders
DNB	Dinitrobenzene
DNT	Dinitrotoluene
FCR	Field Change Request
FS	Feasibility Study
FWCUG	Facility-wide Cleanup Goal
FWGW	Facility-wide Groundwater
FWGWMP	Facility-wide Groundwater Monitoring Program
FWSAP	Facility-wide Sampling and Analysis Plan
gpm	Gallons per Minute
IDW	Investigation-Derived Waste
MCL	Maximum Contaminant Level
NTU	Nephelometric Turbidity Unit
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PCB	Polychlorinated Biphenyl
PP	Proposed Plan
PWS	Performance Work Statement
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RI	Remedial Investigation
RIWP	Remedial Investigation Work Plan
ROD	Record of Decision
RSL	Regional Screening Level
RVAAP	Ravenna Army Ammunition Plant
S.U.	Standard Unit
SVOC	Semivolatile Organic Compound
TNT	2,4,6-Trinitrotoluene
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USP&FO	U.S. Property and Fiscal Officer
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Leidos has been contracted by the U.S. Army Corps of Engineers (USACE), Louisville District to execute the performance work statement (PWS) titled “Groundwater Investigation and Reporting Services, Ravenna Army Ammunition Plant (RVAAP) Restoration Program, Camp James A. Garfield (CJAG) Joint Military Training Center, Portage and Trumbull Counties, Ohio.” This work is being performed under a firm-fixed price basis in accordance with USACE, Louisville District Contract No. W912QR-21-D-0016, Delivery Order No. W912QR22F0186.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigation and cleanup for groundwater within the former RVAAP are occurring under the U.S. Department of Defense Installation Restoration Program. Activities include monitoring an extensive network of groundwater monitoring wells to determine nature and extent of groundwater impacts, providing additional information in support of hydrogeologic and fate and transport models, evaluating potential exit pathways, and evaluating vertical contaminant distribution and/or particle inflow/outflow through the facility.

The former RVAAP is now known as CJAG Joint Military Training Center. The former RVAAP/CJAG is located in Portage and Trumbull Counties, Ohio.

1.1 PURPOSE

The Director’s Final Findings and Orders (DFFO) were issued to the U.S. Department of the Army (Army) on June 10, 2004 (Ohio EPA 2014). The purpose of the DFFO is for the Army to develop and implement:

- A Remedial Investigation (RI)/Feasibility Study (FS), Proposed Plan (PP), Record of Decision (ROD), or other appropriate document and remedy for each area of concern (AOC) or appropriate group of AOCs at the former RVAAP
- A facility-wide groundwater (FWGW) investigation, monitoring, and remediation program at the former RVAAP.

Section 15 of the DFFO outlines the requirements of the Facility-wide Groundwater Monitoring Program (FWGWMP). The purpose of this 2022 Annual Report is to satisfy the requirements of Section 15d, which specifies the FWGWMP Plan will “utilize an iterative process, with an annual review and revision cycle to accommodate the addition or deletion of wells from the groundwater monitoring network.”

1.2 OBJECTIVES

The primary objectives of this 2022 Annual Report are to describe the FWGWMP sampling events that occurred in Spring and Fall 2022, as specified in the *Facility-wide Groundwater Monitoring Addendum for 2022* (Leidos 2022a, herein referred to as the 2022 Addendum) and applicable field change requests (FCRs). This report provides groundwater elevations from the October 2022 facility-wide well gauging event, and analytical results, discussion, conclusions, and recommendations as to how the FWGWMP should proceed. This report also discusses changes to the FWGWMP in 2022.

1.3 REPORT ORGANIZATION

The remaining sections of this 2022 Annual Report are organized as follows:

- Section 2.0 Background
- Section 3.0 Facility Description
- Section 4.0 2022 Monitoring Program
- Section 5.0 Groundwater Elevations
- Section 6.0 2022 Results and Discussion
- Section 7.0 Time-Trend Graphs
- Section 8.0 Conclusions and Recommendations
- Section 9.0 References.

2.0 BACKGROUND

In 2004, the Army and Ohio Environmental Protection Agency (Ohio EPA) finalized the *Facility-wide Groundwater Monitoring Program Plan for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (Portage Environmental 2004) for the former RVAAP, now known as CJAG Joint Military Training Center. The FWGWMP was initiated in April 2005 with quarterly sampling of 36 FWGWMP monitoring wells. Fourteen of these wells were identified as “background wells,” and the remaining wells were located at various AOCs at CJAG.

Five wells historically known as Resource Conservation and Recovery Act (RCRA) wells (RQLmw-007, RQLmw-008, RQLmw-009, DETmw-003, DETmw-004) were incorporated into the FWGWMP after May 2005. As of 2021, these wells are no longer identified as RCRA wells. Sampling groundwater from these wells will be based on decisions made under the CERCLA program.

The FWGWMP monitoring well network currently contains 301 permanent wells. Forty-eight wells were sampled in 2022 under the FWGWMP. In addition to these wells, 17 permanent wells at RVAAP-69 Building 1048 Fire Station and 3 permanent wells at RVAAP-74 Building 1034 Motor Pool Hydraulic Lift are not currently incorporated into the FWGWMP monitoring well network as they were installed and sampled to support their current site-specific investigations. Under the FWGWMP, four of the permanent wells (FWGmw-018, FWGmw-020, FWGmw-021, and FWGmw-024) have historically been referenced as “Offsite Wells.” This term has been used to define wells that are adjacent to State Route 5, outside the perimeter fence of CJAG. However, all four wells are located on federally owned property at CJAG.

Since 2005, the results have been summarized in an annual report. In 2016, the *Remedial Investigation Work Plan for Groundwater and Environmental Services for RVAAP-66 Facility-Wide Groundwater* (TEC-Weston 2016) (herein referred to as the Remedial Investigation Work Plan [RIWP]) was developed. This RIWP served as a supplement to the FWGWMP Plan and specified aspects of the RI with the goal of adequately characterizing pertinent physical and chemical groundwater conditions in the multi-aquifer hydro stratigraphic units variably present across CJAG, so that potential current and future risks to potential human and environmental receptors can be ascertained, effectively managed, and mitigated as needed. The *Remedial Investigation Report for RVAAP-66 Facility-wide Groundwater* (Leidos 2022b) was approved by Ohio EPA in April 2022.

2.1 CERCLA PROCESS

CERCLA, commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of hazardous waste at these sites, and established a trust fund to provide for cleanup when no responsible party could be identified.

The law authorizes two kinds of response actions:

- Short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response; and
- Long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious but not immediately life threatening.

Although the former RVAAP is not on the National Priorities List, the objective of the DFFO was for the Army and Ohio EPA to:

> "Contribute to the protection of public health, safety, and welfare and the environment from the disposal, discharge, or release of contaminants at or from the site, through implementation of a CERCLA-based environmental remediation program. This program will include the development by respondent of an RI/FS for each AOC or appropriate group of AOCs at the site, and upon completion and publication of a PP and ROD or other appropriate document for each AOC or appropriate group of AOCs, the design, construction, operation, and maintenance of the selected remedy as set forth in the ROD or other appropriate document for each AOC or appropriate group of AOCs."

The basic stages of the CERCLA process are as follows:

- Preliminary Assessment/Site Inspection– An initial evaluation of a site to determine if further investigations or responses are necessary.
- RI/FS – A detailed investigation to determine the nature and extent of contamination at a site, test whether certain technologies are capable of treating the contamination, and evaluate the cost and performance of technologies that could be used to clean up the site.
- PP – A plan presented to the public that summarizes the findings of the RI/FS phase, highlighting the key factors that led to identifying a preferred alternative. The PP is made available for public comment.
- ROD – A decision document presenting the remedial action plan for a site that 1) certifies that the remedy selection process was carried out in accordance with CERCLA; 2) describes the technical parameters of the remedy, specifying the methods selected to protect human health and the environment, including treatment, engineering, and institutional control components, as well as cleanup levels; and 3) provides the public with a consolidated summary of information about the site and the chosen remedy, including the rationale behind the selection.
- Remedial Design/Remedial Action – The engineering phase during which additional technical information and data identified are incorporated into technical drawings and specifications developed for the subsequent remedial action and the implementation phase of site cleanup.

The FWGW AOC at the former RVAAP is currently in the RI/FS phase of the CERCLA process.

2.2 GROUNDWATER MODELING

A groundwater flow model used in the RIWP (TEC-Weston 2016) was evaluated and revised (as needed) to conduct the groundwater flow modeling required to support the RI and is summarized in the FWGW RI Report. The groundwater flow model, combined with transport models, is an effective tool for understanding of the groundwater flow system at CJAG and thereby support making more appropriate groundwater management decisions. This model will be again evaluated and revised (as needed) to support the future FS, remedial design, remedial action, and other decision-making process.

2.3 ASSESSMENT OF GROUNDWATER REMEDIAL ACTION EFFECTIVENESS

Groundwater remedial actions have not been conducted at CJAG. Contaminant source removals through soil excavations have been implemented to reduce groundwater impacts. Following the completion of the FWGW FS, a determination will be made as to whether remedial actions are warranted for groundwater.

THIS PAGE INTENTIONALLY LEFT BLANK.

3.0 FACILITY DESCRIPTION

This section provides a brief description of CJAG, describes the site geology and hydrogeology that is pertinent in understanding and evaluating FWGW, and presents the conceptual site model for the FWGW AOC.

3.1 FACILITY DESCRIPTION

The former RVAAP, now known as CJAG, located in northeastern Ohio within Portage and Trumbull Counties, is approximately 3 miles east/northeast of the city of Ravenna and 1 mile north/northwest of the city of Newton Falls (Figure 3-1). The facility is approximately 11 miles long and 3.5 miles wide. The facility is bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad to the south; Garrett, McCormick, and Berry Roads to the west; the Norfolk Southern Railroad to the north; and State Route 534 to the east. In addition, the facility is surrounded by the communities of Windham, Garrettsville, Charlestown, and Wayland. The facility is Federal property, which has had multiple accountability transfers among multiple Army agencies, making the property ownership and transfer history complex. The last administrative accountability transfer occurred in September 2013 when the remaining acreage (not previously transferred) was transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the Ohio Army National Guard (OHARNG) for use as a military training site (Camp James A. Garfield).

3.2 SITE GEOLOGY

Surface geology at CJAG generally consists of glacial till deposits from the Wisconsinan glacial advance, with occasional outcrops of bedrock of the Pottsville formation. North-south trending pre-glacial valleys in the central and western portions of CJAG were generally deepened by scouring and subsequently buried during two minor glacial advances and retreats. The Wisconsinan glacial advances first deposited the Lavery Till and later deposited the Hiram Till. Figure 3-2 depicts the unconsolidated deposits at CJAG.

The uppermost bedrock underlying CJAG consists of several units of the Pennsylvanian-age Pottsville formation, as shown in Figure 3-3. Figure 3-4 is a cross-section location map, and Figures 3-5 and 3 6, adapted from the 2017 Annual Report (TEC-Weston 2018), present cross-sections trending east-west and north-south, respectively, which illustrate the geology underlying CJAG. The Pottsville formation varies significantly in composition both vertically and laterally, ranging from coarse, permeable sandstones to impermeable shales.

Due to the variation in composition, the Pottsville formation is subdivided into the members and units discussed below. The base unit of the Pottsville formation is sandstone, which is locally conglomeratic and underlain by Mississippian-age shale of the Cuyahoga formation (Winslow and White 1966).

3.2.1 Unconsolidated

The surface of the eastern two-thirds of the CJAG property is composed of the clay-rich and relatively impermeable Hiram Till and associated outwash plain deposits. The western third of CJAG is covered by the Lavery Till, a silty, sandy deposit with occasional cobbles and sporadic boulders (Winslow and

White 1966). The first Wisconsinan glacial advance deposited the Lavery Till with a thickness ranging from 20 to 40 feet. The second advance covered only the eastern two-thirds of CJAG, depositing the Hiram Till (Kammer 1982). The Hiram Till consists of 12 percent sand, 41 percent silt, and 47 percent illite and chlorite clay minerals, and ranges in depth from 5 to 15 feet below ground surface (bgs). In the far northeastern corner of CJAG, the Hiram Till overlies thin beds of sandy outwash material. Across CJAG, the thickness of unconsolidated deposits ranges from less than 3 feet to approximately 45 feet (Author unknown 1998; as cited in the Integrated Natural Resources Management Plan [OHARNG 2014]).

3.2.2 Homewood Sandstone

The Homewood Sandstone Member is the uppermost Member of the Pottsville formation, and it is present in the western portion of CJAG. The Homewood Member consists of a range of well-sorted, coarse-grained, white quartzose sandstone to a tan, poorly sorted, clay-bonded, micaceous, medium- to fine-grained sandstone. Thin shale layers are prevalent in the Homewood Member, as indicated by a darker gray. The Homewood Sandstone Member lies unconformably upon the Mercer Member of the Pottsville formation and often forms a caprock (Winslow and White 1966).

3.2.3 Mercer Shale

The Mercer Shale Member consists of silty to carbonaceous shale, thin coal, underclay, and limestone layers with abundant thin, discontinuous sandstone lenses in the upper portion. This member occurs in the western portion of CJAG along eroded/incised slopes; however, it is not well documented at CJAG. The Mercer Member is underlain by the Massillon Sandstone Member (Winslow and White 1966).

3.2.4 Massillon Sandstone

The Massillon Sandstone Member consists of coarse- to medium-grained micaceous sandstone beds, which are commonly cross-bedded and often separated by shale beds. The separating silty sandy shale beds can be up to 50 feet thick and contain plant fragments. The sandstone beds contain rounded granules and quartz pebbles in some locations but do not create thick conglomerate beds. The Massillon Sandstone unconformably overlies the Shale unit of the Sharon Member of the Pottsville formation (Winslow and White 1966).

3.2.5 Sharon Shale

The Sharon Member of the Pottsville formation contains two distinct units: the Upper Sharon and the Basal Sharon Conglomerate. The Upper Sharon is composed of thin gray to black sandy to micaceous shale lenses, containing thin coal, underclay, and sandstone lenses. This unit is present in the western portion of CJAG but was eroded from the eastern portion of the property before the Massillon Sandstone was deposited. The Sharon Shale unit overlies the Sharon Sandstone/Conglomerate unit (Winslow and White 1966).

3.2.6 Basal Sharon Conglomerate

The Basal Sharon Conglomerate unit is the basal portion of the Pottsville formation and is a highly porous, loosely cemented, permeable, cross-bedded, frequently fractured, and weathered sandstone. The conglomerate portion consists of well-rounded quartz pebbles and granules with little sand-sized matrix or cement. The conglomerate typically occurs within the lower (deeper) portions of the unit, which lies unconformably upon the Mississippian-age shale of the Cuyahoga formation (Winslow and White 1966).

3.2.7 Cuyahoga Shale

The Meadville Shale is the uppermost unit of the Mississippian-age Cuyahoga Group. It consists of micaceous, blue-gray sandy shale with flagstone and clay-ironstone layers. The Meadville Shale overlies the Sharpsville Sandstone of the Cuyahoga Group, which overlies the Orangeville Shale of the Cuyahoga Group (Winslow and White 1966). While previously mapped in limited extent on the eastern portion of CJAG (Portage Environmental 2004), subsequent studies (TEC-Weston 2016) indicate the mapped unit is actually the Sharon Member.

3.3 SITE HYDROGEOLOGY

Throughout CJAG, depth to groundwater ranges from less than 2 feet bgs to more than 118 feet bgs, with static water elevations occurring from approximately 928 to 1,176 feet above mean sea level (amsl). Table 3-1 provides the aquifer depths relative to ground surface and sea level. Observed gradients indicate groundwater flows from bedrock highs in the western portion of the property toward stream valleys in the eastern portion.

Table 3-1. Aquifer Depths Relative to Ground Surface and Sea Level

	Aquifer Depths			
	Below Ground Surface		Elevation	
Aquifer	Minimum Depth (ft bgs)	Maximum Depth (ft bgs)	Upper Elevation (ft amsl)	Lower Elevation (ft amsl)
Unconsolidated	2.92	116.79	928.99	1,151.45
Homewood	1.60	45.23	942.02	1,137.42
Upper Sharon	5.39	118.12	936.93	1,175.70
Basal Sharon Conglomerate	2.75	42.15	935.83	1,104.06

amsl = Above Mean Sea Level
bgs = Below Ground Surface
ft = Feet

The majority of CJAG is composed of clay-rich glacial tills with low permeability and underlying bedrock formations with extremely variable, but relatively low, permeability. Typical yields from wells were reported in the 1982 study as penetrating the "Sharon Conglomerate" range from 5 to 200 gallons per minute (gpm); yields from the overlying unconsolidated deposits are usually considerably lower. In addition, the thickness and permeability of the bedrock water-bearing formations at CJAG vary considerably and have a strong effect on well yields, transmissivity, and hydraulic conductivity (Kammer 1982).

3.3.1 Unconsolidated

Groundwater occurs within the unconsolidated deposits in many areas of the facility. The thickness of the unconsolidated deposits at the facility ranges from thin to absent in the eastern and northeastern portions of the facility to an estimated 150 feet in pre-glacial valleys near the central portion of the facility. Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow paths likely exhibit local variations, which are difficult to determine.

The hydraulic gradient in the Unconsolidated aquifer predominantly trends in an eastward direction; however, the unconsolidated zone shows numerous local flow variations influenced by topography and stream drainage patterns, with localized flow along preferential pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities than surrounding clay or silt-rich material. The local variations in flow direction suggest 1) groundwater in the unconsolidated deposits is generally in direct hydraulic communication with surface water, and 2) surface water drainageways may also act as groundwater discharge locations. In addition, topographic ridges between surface water drainage features act as groundwater divides in the unconsolidated deposits.

At CJAG, and the regions surrounding, groundwater recharge occurs via surface infiltration of precipitation along root zones, desiccation cracks, partings within the soil column, and general percolation through sand and gravel within buried valleys. Two large, buried valleys occur southwest and northwest of the facility; wells in the Unconsolidated aquifers in these valleys can yield up to 1,600 gpm. Monitoring wells that currently exist in unconsolidated material on the CJAG property range from 14 to 130 feet bgs. Figure 5-1 shows the potentiometric surface of groundwater in unconsolidated material within the facility in October 2022 flowing to the east.

3.3.2 Homewood Sandstone

The uppermost bedrock aquifer at CJAG is the Homewood Sandstone, which is reportedly only capable of well yields less than 10 gpm (Kammer 1982). The Homewood aquifer is present in the central and western portions of the property. It is usually bound above by unconsolidated glacial till and below by the Mercer Member. Existing monitoring wells screened within the Homewood Sandstone Member range from 19 to 50 feet bgs. Figure 5-2 shows the potentiometric surface of Homewood Sandstone groundwater within the facility in October 2022.

Review of regional geology maps (Winslow and White 1996) and historical monitored formation interval designations at CJAG during preparation of the RIWP (TEC-Weston 2016) indicated certain groundwater monitoring wells near the Fuze and Booster Quarry, including Load Lines 5 through 10, known as Fuze and Booster Hill, were likely incorrectly identified to be installed within the Homewood Sandstone formation.

3.3.3 Upper Sharon

The principal water-bearing aquifer at CJAG is the Sharon Sandstone/Conglomerate unit of the Pottsville formation. Depending on the existence and depth of overburden, the Sharon Sandstone/Conglomerate unit ranges from an unconfined to a leaky artesian (semi-confined) aquifer. The Sharon Shale is a confining unit to the Upper Sharon aquifer where present in the western portion of the property. Water yields from area wells completed in the Sharon Sandstone/Conglomerate unit range from 30 to 400 gpm (USATHAMA 1978). Well yields of 5 to 200 gpm were reported for onsite bedrock wells completed in the Sharon Sandstone/Conglomerate unit (Kammer 1982). Existing monitoring wells screened within the Upper Sharon unit, including those in the Sharon Shale, range from 12.6 to 213.5 feet bgs.

Figure 5-3 shows the potentiometric surface of Upper Sharon groundwater within the facility in October 2022. This bedrock potentiometric map shows a more uniform and regional eastward flow direction that is less affected by local surface topography than unconsolidated material and Homewood Sandstone groundwater.

3.3.4 Basal Sharon Conglomerate

The Sharon Sandstone/Conglomerate unit is the most productive unit of the Pottsville formation and is the major bedrock aquifer in northeastern Ohio. A 1982 study reported that of the 71 groundwater wells that had been installed at the installation, 57 were completed in the Sharon Conglomerate, differing from the Basal Sharon Conglomerate aquifer currently described for CJAG. Data from the 1982 study indicated that the thickness of the Sharon Conglomerate ranges from 44 to 177 feet (Kammer 1982). Existing monitoring wells screened within the Sharon Conglomerate range from 90 to 277 feet bgs.

Figure 5-4 shows the potentiometric surface of Basal Sharon Conglomerate groundwater within the facility in October 2022. The bedrock potentiometric map shows a more uniform and regional eastward flow direction that is less affected by local surface topography than the overlying aquifers.

THIS PAGE INTENTIONALLY LEFT BLANK.

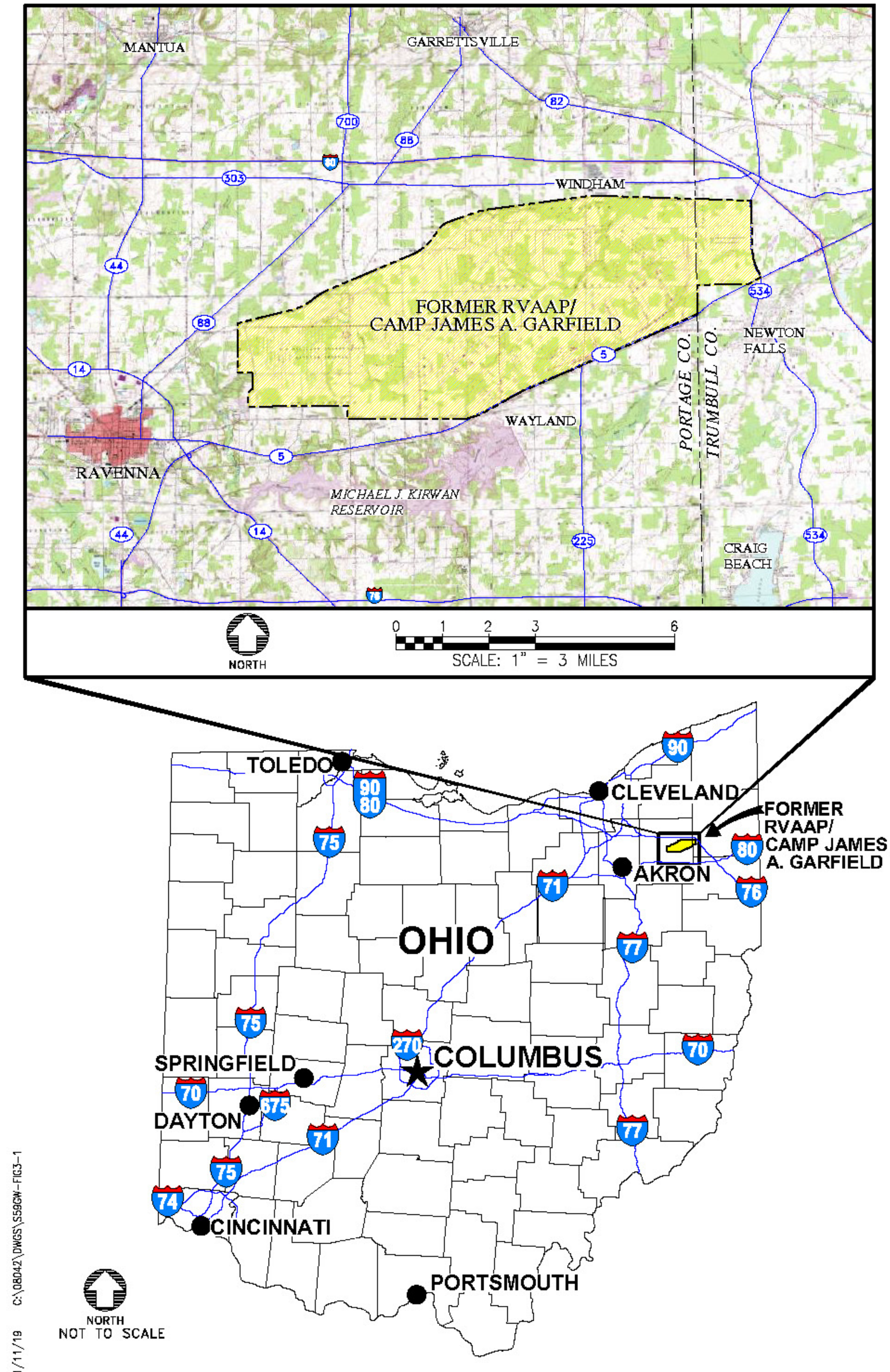


Figure 3-1. General Location and Orientation of Camp James A. Garfield

THIS PAGE INTENTIONALLY LEFT BLANK.

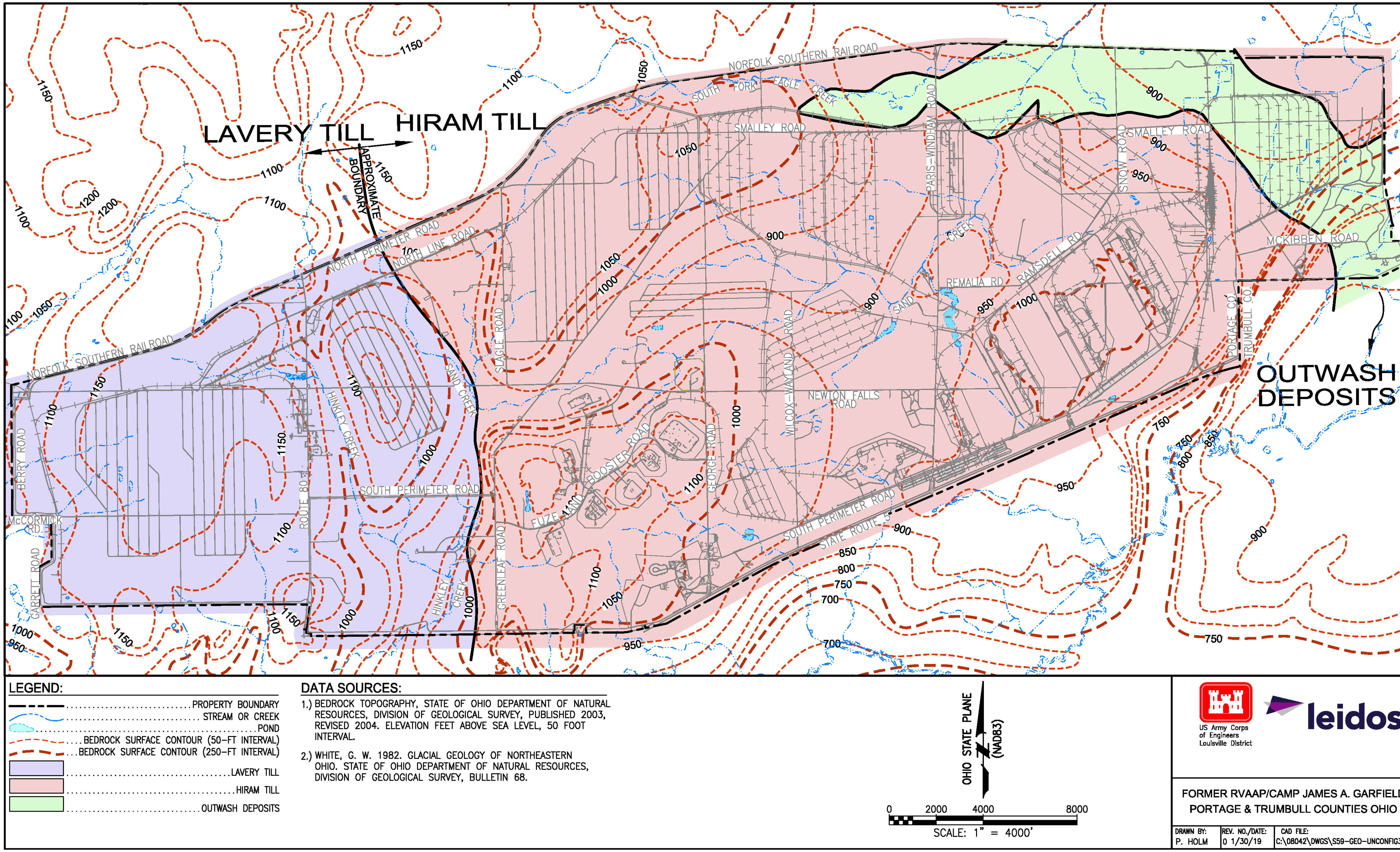


Figure 3-2. Geologic Map of Unconsolidated Deposits at Camp James A. Garfield

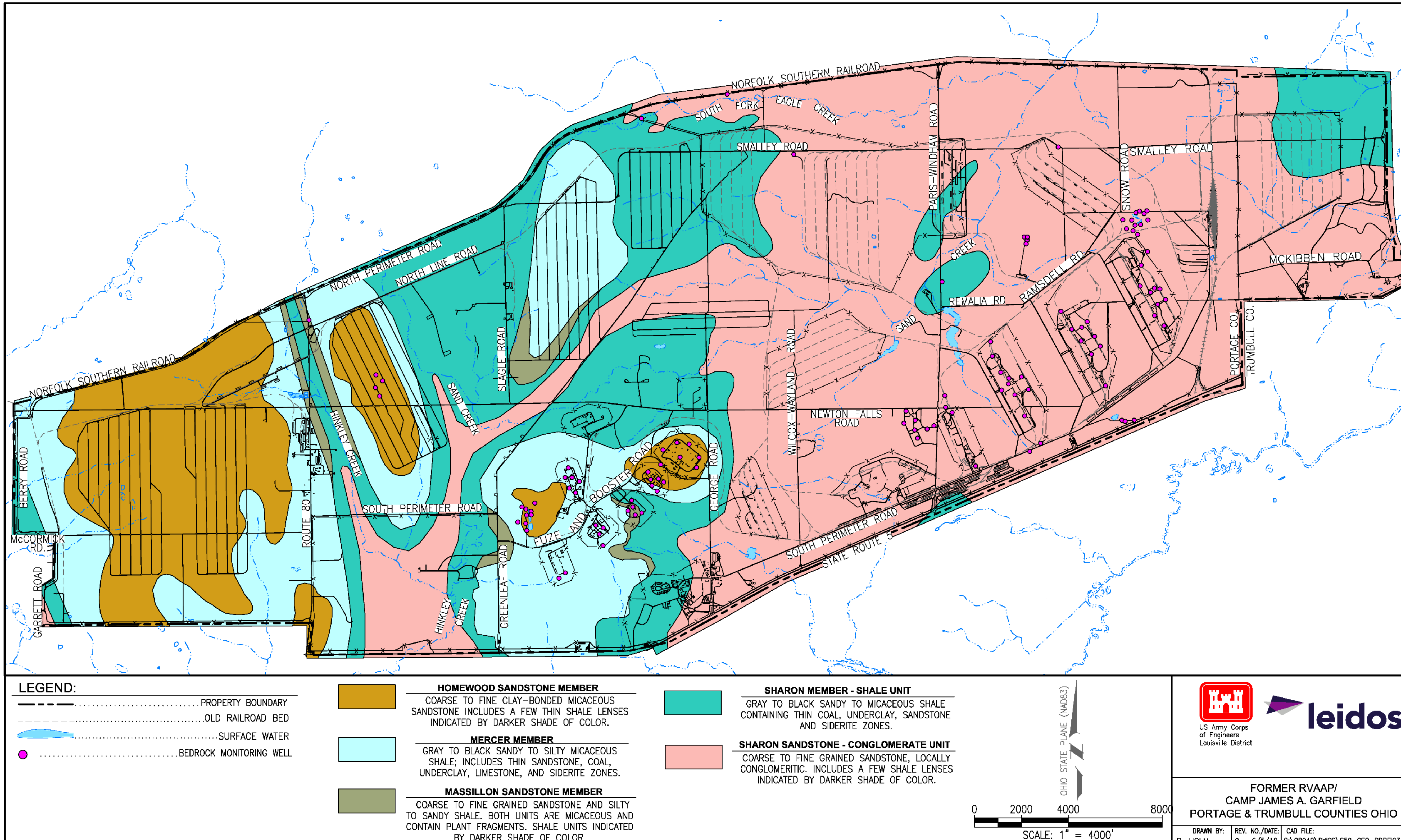


Figure 3-3. Geologic Bedrock Map and Stratigraphic Description of Units at Camp James A. Garfield

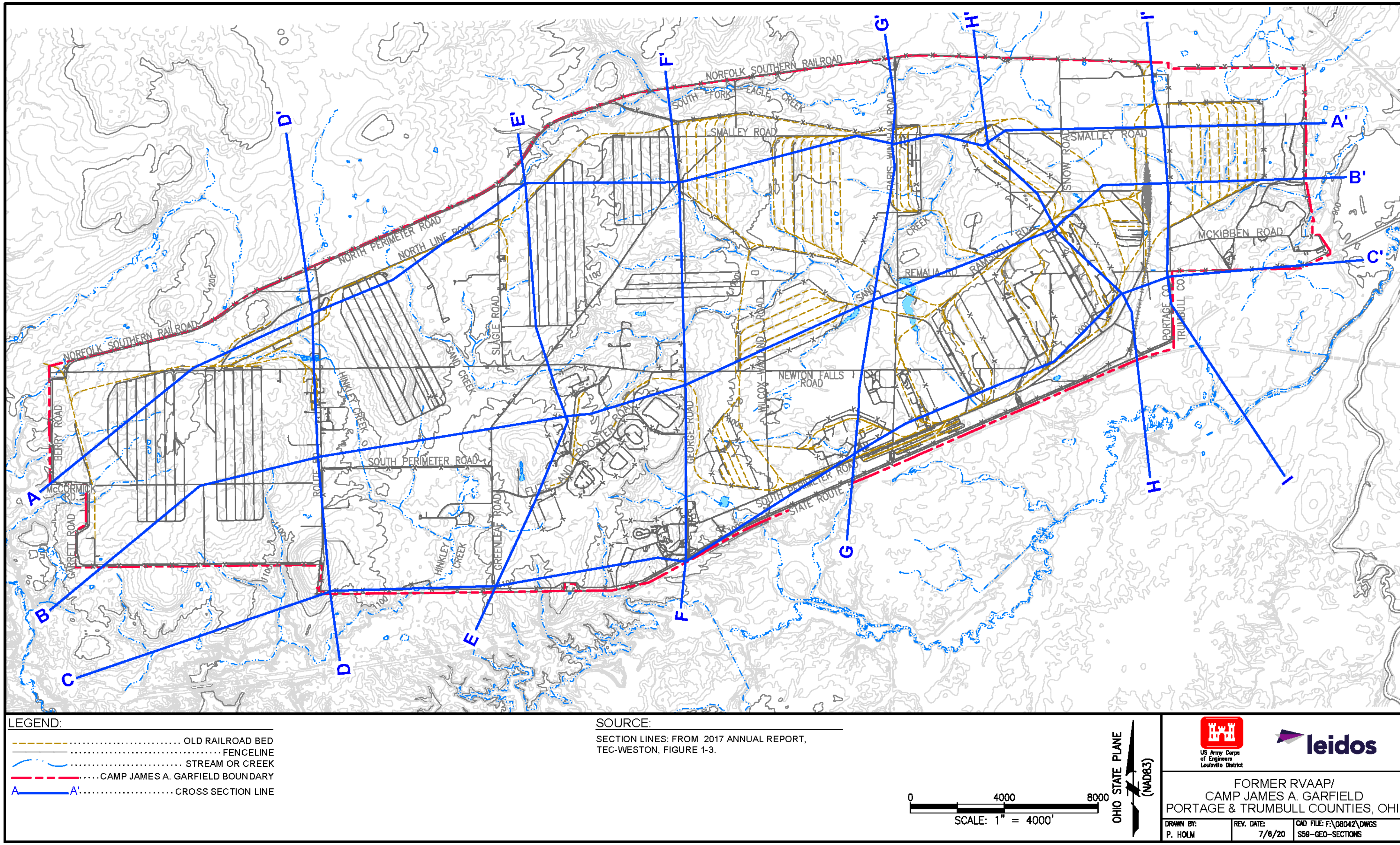


Figure 3-4. Line of Section Map

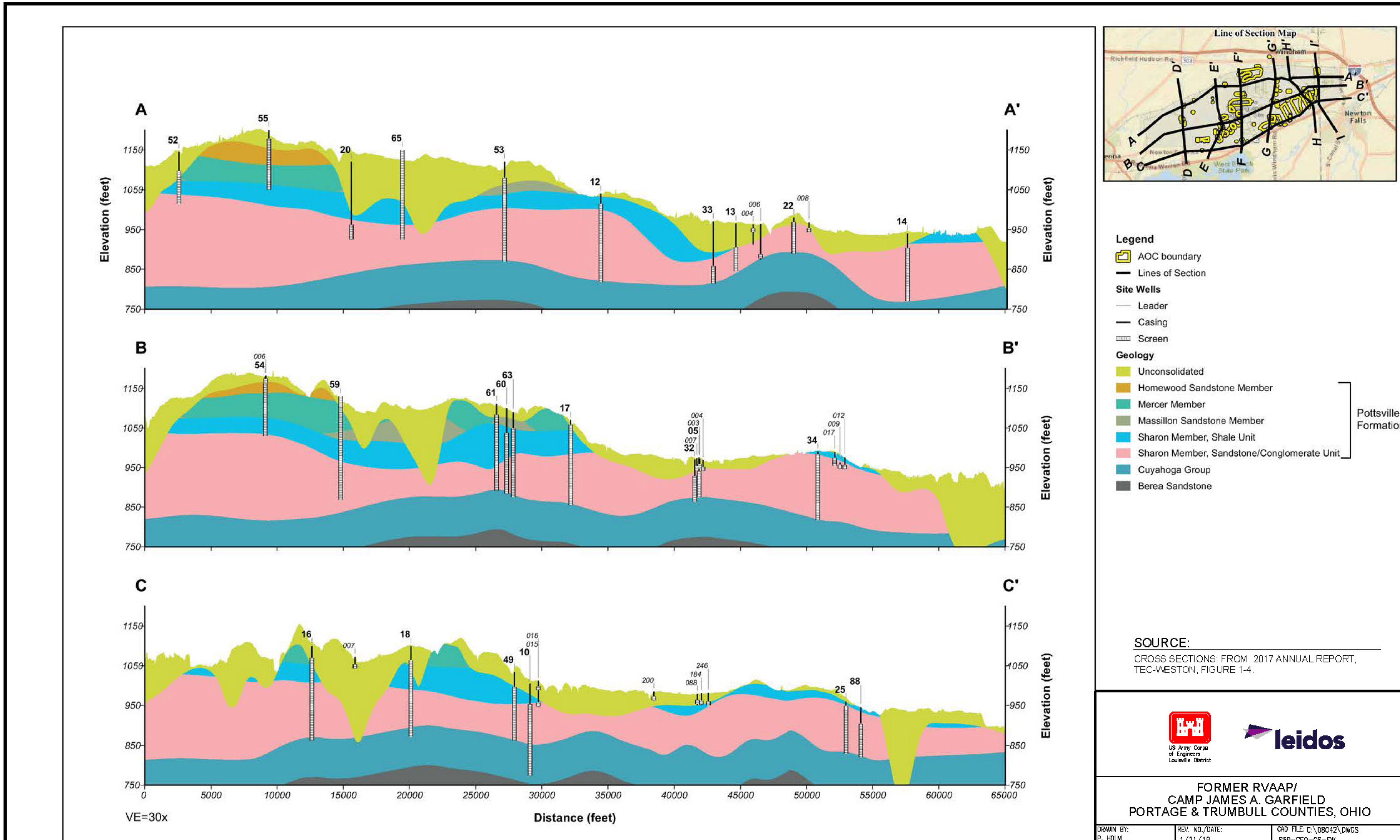


Figure 3-5. East-West Cross-Sections (A-C)

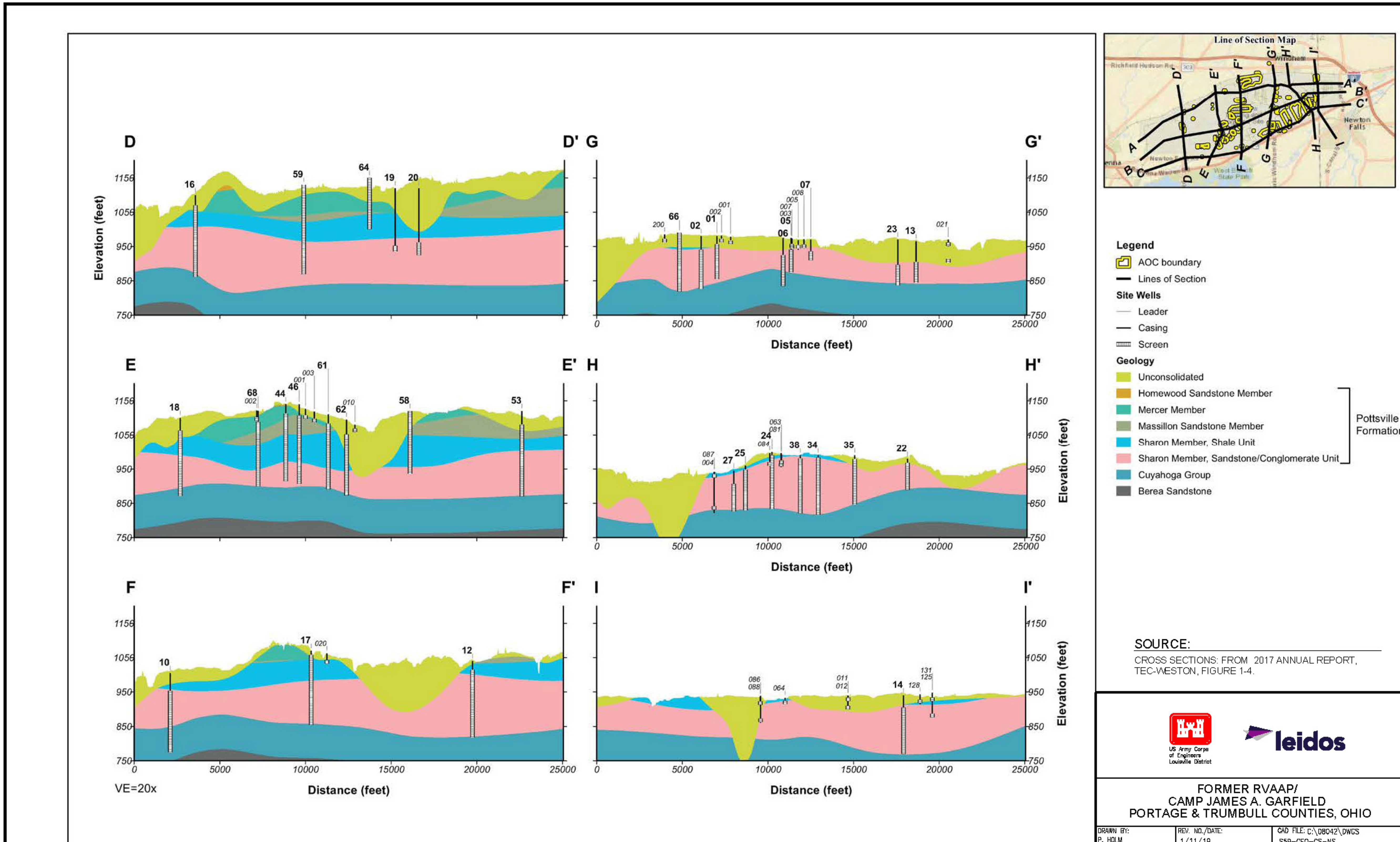


Figure 3-6. North-South Cross-Sections (D-I)

THIS PAGE INTENTIONALLY LEFT BLANK.

4.0 2022 MONITORING PROGRAM

This section summarizes activities conducted during implementation of the 2022 monitoring program. Monitoring well construction details are presented in Appendix A.

4.1 MONITORING WELL GAUGING AND INSPECTIONS

From October 24 to October 26, 2022, Leidos conducted the annual groundwater elevation monitoring event (discussed in Section 5.1). During this event, permanent monitoring wells within the FWGWMP monitoring well network were inspected, the condition of each well was documented, and the groundwater water elevations were recorded. The groundwater elevations for B12mw-011, B12mw-012, BKGmw-021, DETmw-004, FBQmw-171, FBQmw-174, LL1mw-063, LL1mw-065, LL1mw-084, LL1mw-085, LL1mw-087, LL3mw-235, LL3mw-237, LL3mw-238, LL3mw-241, LL6mw-001, LL6mw-002, LL6mw-006, LL6mw-008, LL12mw-189, RQLmw-017, SCLmw-001, SCLmw-002, and SCLmw-003 were unable to be obtained due to the top of the permanent pump being above the groundwater level. The groundwater elevation for DA2mw-106, DA2mw-112, and FWGmw-004 was unable to be obtained due to an active bee's nest within the well vault.

The 2022 monitoring well inspection report was provided to the Army and contained the well inspection field forms and photographs. The groundwater monitoring well conditions and repair recommendations are summarized in Appendix B.

4.2 MONITORING WELL SAMPLING EVENTS

The following subsections summarize the two semi-annual sampling events that were conducted in 2022 per the 2022 Addendum (Leidos 2022a). Tables 4-1 and 4-2 summarize wells sampled in 2022 and the associated chemical groups that were analyzed. Figure 4-1 presents the locations of all wells sampled in 2022. Appendix C contains the reports, logbooks, calibration logs, and purge forms associated with 2022 field events, and Appendix D presents the laboratory analytical results.

4.2.1 Spring 2022 Sampling Event

The Spring 2022 sampling event was conducted from June 14 to June 28, 2022. In accordance with the 2022 Addendum (Leidos 2022a), 48 monitoring wells were sampled during the first semi-annual event of 2022. The overall results of the Spring 2022 sampling event are discussed further in Section 6.0.

4.2.2 Fall 2022 Sampling Event

The Fall 2022 sampling event was conducted from September 27 to October 5, 2022. Forty-six of the 48 wells specified in the 2022 Addendum (Leidos 2022) were sampled. The following addresses the two wells that were not able to be sampled:

- FBQmw-174 was purged dry while attempting to attain stability. Another attempt at collection was made within 24 hours; however, no water could be produced for the sample.
- At FWGmw-004, a hornet's nest prevented safe access to the well, and the well was not sampled. This was documented in FCR LEIDOS_FWGW_012 (Appendix H).

Monitoring well LL1mw-063 was also purged dry while attempting to attain stability. The sample from LL1mw-063 was collected over the course of 2 days as a composite sample; each time, the well was purged dry and another attempt at collection was made within 24 hours. The overall results of the Fall 2022 sampling event are discussed further in Section 6.0.

4.3 SEDIMENTATION AND TURBIDITY

The following subsections describe the wells that were redeveloped in 2022, summarize the turbidity readings at the time of sample collection in 2022, and provide recommendations of wells to be redeveloped in the future.

4.3.1 Well Redevelopment Activities

No wells were redeveloped during field activities in 2022.

4.3.2 Turbidity Results

Historically, elevated turbidity readings have been measured in many of the RVAAP restoration program monitoring wells. Mitigation efforts to reduce elevated turbidity in groundwater samples were implemented in 2016. The primary approach to reduce turbidity was to install permanent bladder pumps in the monitoring wells that are to be sampled on a regular basis. The permanent pumps eliminate the need to lower and raise equipment in the well, which disturbs the sediment at the bottom of the well.

Wells sampled in 2022 used previously installed bladder pumps, with the exceptions noted below:

- During the Spring event, the dedicated pumps at WBGmw-006, WBGmw-009, WBGmw-014, WBGmw-018, WBGmw-020, and WBGmw-021 were pulled because the wells were converted to flush mounts. Prior to the fall event, the dedicated pumps were reinstalled.
- Non-dedicated pumps were set in LL1mw-082, LL12mw-246, WBGmw-016, and WBGmw-017 for a minimum of 48 hours prior to sampling during both events in 2022 and will continue for future sampling events.
- Monitoring well SCFmw-004 is known to become artesian; therefore, a well packer is used to inhibit groundwater from perpetually flooding the well casing. The well was only artesian during the Spring 2022 event. A minimum of 48 hours prior to the Spring sampling event, the well packer was removed and a bladder pump was installed.

Turbidity was measured during groundwater sampling using Aqua TROLL 600 Multiparameter Sondes during the Spring and Fall 2022 sampling events. In accordance with turbidity stabilization requirements for sampling procedures at the facility, turbidity was considered stable when readings less than or equal to 10 nephelometric turbidity units (NTUs) were achieved or the turbidity was less than 50 NTUs after 2 hours of purging the well.

The Spring 2022 sampling event included collecting groundwater samples from 48 monitoring wells. Forty-three of the 48 wells had turbidity readings between 0 and 10 NTUs, 3 of the wells had turbidity readings between 10 and 50 NTUs, and 2 of the wells (LL1mw-064 andLL1mw-086) had turbidity readings greater than 50 NTUs. No metal analysis was required for LL1mw-064or LL1mw-086;

therefore, no filtered samples were collected at these wells during the Spring 2022 sampling event. Table 4-4 presents all final turbidity readings from the Spring 2022 sampling event.

The Fall 2022 sampling event included collecting groundwater samples from 46 monitoring wells. Thirty-seven of the 46 wells had turbidity readings between 0 and 10 NTUs, 4 of the wells were between 10 and 50 NTUs, and 4 of the wells (LL2mw-059, LL1mw-086, LL12mw-244, and LL12mw-245) had final turbidity readings greater than 50 NTUs. One of the wells (LL1mw-063) was sampled over the course of 2 days due to the well continually going dry, although field notes indicate that the water was clear. No metal analysis was required at any of these four wells; therefore, no filtered samples were collected at these wells during the Fall 2022 sampling event. Table 4-5 presents all final turbidity readings from the Fall 2022 sampling event.

4.3.3 Well Redevelopment Recommendations

As part of the ongoing FWGWMP, wells will be selected for redevelopment to remove accumulated sediment and fines from the filter packs. Redevelopment of monitoring wells, as stated in the RIWP (TEC-Weston 2016), will occur if one of the following criteria is met:

- Monitoring wells have turbidity levels between 10 and 20 NTUs, if there is greater than 0.5 feet of sedimentation in the bottom of the well, all previous rounds showed exceedingly high NTUs, and the well is a non-producer (i.e., low yield).
- Turbidity levels were greater than 20 NTUs, unless turbidity levels were less than 10 NTUs in the three previous rounds and unless the well is located within a naturally high-turbidity water-bearing zone/aquifer.

An additional consideration of target analytes also will be made when addressing if a well requires redevelopment. For example, if a monitoring well is not going to be sampled and analyzed for metals, it may be determined that well redevelopment is unnecessary.

Wells that had turbidity readings greater than 10 NTUs in 2022 are summarized below and recommendations (if necessary) are provided:

- FWGmw-021
  - Turbidity was 8.2 NTUs in Spring 2022 and 21.98 NTUs in Fall 2022. The three previous samples prior to 2022 had a turbidity greater than 10 NTUs.
  - This well is not recommended for redevelopment in 2023.
- LL1mw-064
  - Turbidity was 85.84 NTUs in Spring 2022 and 4.3 NTUs in Fall 2022. The three previous samples prior to 2022 had a turbidity less than 10 NTUs.
  - Due to the recent increase in turbidity readings, this well should be considered for redevelopment prior to sampling in 2023.
- LL1mw-082
  - Turbidity was 9.19 NTUs in Spring 2022 and 27.14 NTUs in Fall 2022. The two previous samples prior to 2022 had a turbidity equal to or less than 10 NTUs. Monitoring well LL1mw-082 was not sampled in 2019 or 2020.
  - This well is not recommended for redevelopment in 2023.

- LL1mw-086
  - Turbidity was 52.06 NTUs in Spring 2022 and 60.51 NTUs in Fall 2022. The three previous samples prior to 2022 had a turbidity greater than 10 NTUs.
  - Due to the recent increase in turbidity readings, this well should be considered for redevelopment prior to sampling in 2023.
- LL12mw-244
  - Turbidity was 0.69 NTUs in Spring 2022 and 3,258.20 NTUs in Fall 2022. The previous two samples prior to 2022 had a turbidity greater than 10 NTUs. Monitoring well LL12mw-244 was not sampled in 2019 or 2020.
  - This well was redeveloped in 2021. Due to the recent increase in turbidity readings, this well should be considered for redevelopment prior to sampling in 2023.
- LL2mw-059
  - Turbidity was 6.39 NTUs in Spring 2022 and 131.09 NTUs in Fall 2022. The three previous samples prior to 2021 had a turbidity less than 10 NTUs.
  - This well is not recommended for redevelopment in 2023 but should be assessed during future sampling events given the recent turbidity was greater than 50 NTUs.
- FWGmw-011
  - Turbidity was 17.74 NTUs in Spring 2022 and 33.90 NTUs in Fall 2022. The three previous samples prior to 2022 had a turbidity greater than 10 NTUs.
  - This well is not recommended for redevelopment in 2023.
- LL12mw-245
  - Turbidity was 4.86 NTUs in Spring 2022 and 642.36 NTUs in Fall 2022. The previous two samples prior to 2022 had turbidity less than 10 NTUs. Monitoring well LL12mw 245 was not sampled in 2020 or 2019.
  - This well is not recommended for redevelopment in 2023 but should be assessed during future sampling events given the recent turbidity was greater than 50 NTUs.
- WBGmw-016
  - Turbidity was 17.28 NTUs in Spring 2022 and 9.23 NTUs in Fall 2022. Monitoring well WBGmw-016 was not sampled in 2021, 2020 or 2019.
  - This well is not recommended for redevelopment in 2023.
- WBGmw-017
  - Turbidity was 13.66 NTUs in Spring 2022 and 18.7 NTUs in Fall 2022. Monitoring well WBGmw-017 was not sampled in 2021, 2020, or 2019.
  - This well is not recommended for redevelopment in 2023.

As per recommendations of previous annual reports, LL12mw-242, and FWGmw-002 should be considered for redevelopment if they are to be sampled in the future. These wells were not sampled in 2022.

4.4 pH MONITORING

As part of each sampling event, field parameter readings of pH are collected during the purging and well stabilization process, as presented in Tables 4-4 and 4-5 for Spring and Fall 2022, respectively. The typical pH range for groundwater in the vicinity of the facility is approximately 5 to 9 standard units (S.U.).

The FWGW RI Report (Leidos 2022b) evaluated pH at the facility. The average pH of each group evaluated in the FWGW RI Report was greater than 5, and 13 of 15 groups had an average pH greater than 6. Based on a well-by-well assessment, it was determined that four groups within CJAG warranted an evaluation of whether previous activities have impacted the pH of groundwater. These groups, and the specific sites requiring an assessment, are listed below:

- Group A – C Block Quarry
- Group D – Fuze and Booster Quarry
- Group H – Load Line 1
- Group I – Ramsdell Quarry Landfill.

In assessing upgradient and downgradient wells, it was determined that groundwater at C Block Quarry and the Fuze and Booster Quarry was not impacted by historical activities, as a significant reduction in pH did not occur. For Ramsdell Quarry Landfill and Load Line 1, the composition of this highly heterogeneous rock may cause some phenomena to occur at a certain location that is producing a significant amount of carbon dioxide, thereby decreasing the groundwater pH in this location. The observed sulfate and chloride ions were evaluated at the specific wells, and based on this evaluation, no indication was found that the groundwater in this area is contaminated by stronger acids that would reduce the pH.

Accordingly, if the pH in sampled wells is less than 5 S.U. or greater than 9 S.U., the wells will be discussed in this report. However, this report does not provide time-based graphs of pH for selected wells.

4.5 LABORATORY ANALYSIS

For the FWGWMP samples collected in 2022, White Water Associates in Amasa, Michigan, and their subcontracted partner, Eurofins in Denver, Colorado, conducted the sample analyses. Appendix D contains the laboratory data associated with the Spring and Fall 2022 sampling events.

4.6 DATA VALIDATION

Appendix F contains the laboratory data packages and data quality assessment reports associated with the Spring and Fall 2022 sampling events.

4.7 GROUNDWATER ANALYTICAL RESULTS

The groundwater analytical results for the Spring and Fall 2022 sampling events are presented in Appendix D. The tables in this appendix present the groundwater results by analyte group (e.g., volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs]) and indicate the AOC and aquifer associated with each monitoring well, as applicable. The tables also include the appropriate screening level and identify data that are equal to or exceed the screening level. Table 4-6 presents summary statistics of field parameters and chemical analysis by aquifer from the samples collected in 2022.

4.8 INVESTIGATION-DERIVED WASTE

During the Spring and Fall 2022 FWGWMP sampling events, six 55-gallon drums of liquid investigation-derived waste (IDW) were generated. IDW was classified as non-hazardous waste based on analytical results and generator knowledge.

The IDW generated in 2022 consisted of the following:

- Purge water collected from monitoring wells during low-flow sampling activities. Minimal purge water IDW volume was generated during sampling because of the use of dedicated sampling equipment.
- Decontamination fluids used to decontaminate instruments and equipment before and after purging and sampling at each monitoring well.

Purge water and decontamination fluids were transferred to staged drums within Building 1036 by the end of each day. All drums were properly labeled and inspected.

During the Spring 2022 sampling event, three 55-gallon drums of liquid IDW were generated. This IDW was classified as non-hazardous waste based on analytical results. On December 15, 2022, the three IDW drums were properly transported and disposed of as non-hazardous waste at a permitted wastewater treatment plant. Appendix G contains the IDW Waste Characterization and Disposal Report, waste profiles, waste manifests, and supporting laboratory data.

During the Fall 2022 well sampling event, three 55-gallon drums of liquid IDW were generated. This IDW was classified as non-hazardous using generator knowledge (based on prior analytical results). On December 15, 2022, the three IDW drums were properly transported and disposed of. Appendix G contains the IDW Waste Characterization and Disposal Report, waste profiles, waste manifests, and supporting laboratory data.

4.9 FIELD CHANGE REQUESTS

FCR LEIDOS_FWGW_012 was approved after the Fall 2022 sampling event. This and all applicable FCRs related to the 2022 FWGWMP sampling events are summarized below and presented in Appendix H:

- LEIDOS_FWGW_001 – Specifies that total depths of wells will not be measured during the facility-wide comprehensive water level measurements due to the permanent bladder pumps.
- LEIDOS_FWGW_004 – Specifies the field quality control sampling frequency.
- LEIDOS_FWGW_006 – Documents the micro-purge procedure to be implemented during groundwater sampling collected by micro-purging with dedicated bladder pumps.
- LEIDOS_FWGW_010 – Specifies that post-sample water quality parameters may not be an accurate characterization of groundwater, and water quality parameters recorded at the time of stabilization (before sampling) are the parameters used for evaluation.
- LEIDOS_FWGW_012 – Specifies that, for the safety of the field team, FWGmw-004 was not sampled during the Fall 2022 Sampling Event because of the wasp nest inside the well casing.

Table 4-1. Wells Sampled and Chemical Groups Analyzed in Spring 2022

No.	RVAAP-66 Area	Well Name	Aquifer	Metals	Explosives	Expanded Explosives (1)	VOCs	SVOCs (2)	Phthalates/ Nitroaromatics/ Phenols	PAHs	PCBs	Pesticides	Cyanide	Nitrate	Ammonia	MNA Suite (3)
1	RVAAP-04 Open Demolition Area #2	DETmw-003	Unconsolidated	X	X		X		X	X	X	X	X			
2	RVAAP-04 Open Demolition Area #2	DETmw-004	Unconsolidated	X	X		X		X	X	X	X	X			
3	RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	Unconsolidated		X	X										X
4	RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	Unconsolidated		X	X										X
5	RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	Unconsolidated		X	X										
6	RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	Unconsolidated		X	X										
7	RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	Unconsolidated		X	X										
8	RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	Unconsolidated		X	X										X
9	RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	Upper Sharon		X	X										
10	RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	Upper Sharon		X	X										
11	RVAAP-08 Load Line 1	LL1mw-063	Unconsolidated		X	X										
13	RVAAP-08 Load Line 1	LL1mw-064	Unconsolidated		X	X										
12	RVAAP-08 Load Line 1	LL1mw-080	Upper Sharon		X	X										
14	RVAAP-08 Load Line 1	LL1mw-081	Upper Sharon		X											
15	RVAAP-08 Load Line 1	LL1mw-082	Upper Sharon		X	X										
16	RVAAP-08 Load Line 1	LL1mw-083	Upper Sharon		X	X										X
17	RVAAP-08 Load Line 1	LL1mw-084	Upper Sharon		X	X										X
18	RVAAP-08 Load Line 1	LL1mw-086	Unconsolidated		X	X										
19	RVAAP-08 Load Line 1	LL1mw-087	Unconsolidated		X	X										
20	RVAAP-08 Load Line 1	LL1mw-089	Unconsolidated		X	X										
21	RVAAP-09 Load Line 2	LL2mw-059	Upper Sharon		X	X										X
22	RVAAP-10 Load Line 3	LL3mw-237	Upper Sharon		X	X										
23	RVAAP-10 Load Line 3	LL3mw-238	Upper Sharon		X	X										X
24	RVAAP-10 Load Line 3	LL3mw-239	Upper Sharon		X	X										X
25	RVAAP-10 Load Line 3	LL3mw-241	Upper Sharon		X	X										
26	RVAAP-10 Load Line 3	LL3mw-245	Upper Sharon		X	X										
27	RVAAP-12 Load Line 12	LL12mw-185	Unconsolidated											X	X	
28	RVAAP-12 Load Line 12	LL12mw-187	Unconsolidated											X	X	
29	RVAAP-12 Load Line 12	LL12mw-244	Unconsolidated											X	X	
30	RVAAP-12 Load Line 12	LL12mw-245	Unconsolidated											X	X	
31	RVAAP-12 Load Line 12	LL12mw-246	Unconsolidated											X	X	
32	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	Homewood		X	X										X
33	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-174	Homewood		X	X										X
34	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	Homewood		X	X										
35	RVAAP-43 Load Line 10	LL10mw-003	Homewood				X									
36	RVAAP-66 Facility-wide Groundwater	FWGmw-004	Unconsolidated		X											
37	RVAAP-66 Facility-wide Groundwater	FWGmw-007	Unconsolidated		X											
38	RVAAP-66 Facility-wide Groundwater	FWGmw-010	Unconsolidated		X	X										
39	RVAAP-66 Facility-wide Groundwater	FWGmw-011	Unconsolidated		X											
40	RVAAP-66 Facility-wide Groundwater	FWGmw-012	Upper Sharon		X											
41	RVAAP-66 Facility-wide Groundwater	FWGmw-015	Unconsolidated		X											
42	RVAAP-66 Facility-wide Groundwater	FWGmw-016	Upper Sharon		X											
43	RVAAP-66 Facility-wide Groundwater	FWGmw-018	Basal Sharon											X		
44	RVAAP-66 Facility-wide Groundwater	FWGmw-020	Upper Sharon											X		
45	RVAAP-66 Facility-wide Groundwater	FWGmw-021	Upper Sharon		X											
46	RVAAP-66 Facility-wide Groundwater	FWGmw-023	Upper Sharon		X	X										

Table 4-1. Wells Sampled and Chemical Groups Analyzed in Spring 2022 (Continued)

No.	RVAAP-66 Area	Well Name	Aquifer	Metals	Explosives	Expanded Explosives (1)	VOCs	SVOCs (2)	Phthalates/ Nitroaromatics/ Phenols	PAHs	PCBs	Pesticides	Cyanide	Nitrate	Ammonia	MNA Suite (3)
47	RVAAP-66 Facility-wide Groundwater	FWGmw-024	Upper Sharon		X											
48	RVAAP-66 Facility-wide Groundwater	SCFmw-004	Unconsolidated		X											

X = Indicates well or constituent to be sampled as part of the 2022 FWGWMP.
(1) Expanded explosives list includes 3,5-dinitroanaline, hexahydro-1,3,5-trinitroso-1,3,5-triazine, hexahydro-1,3-dinitroso-5-dinitro-1,3,5-triazine, hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine, 2,4-diamino-6-nitrotoluene, and 2,6-diamino-4-nitrotoluene.
(2) SVOCs include phthalates, nitroaromatics, PAHs, and phenols.
(3) MNA suite includes anions, total organic carbon, alkalinity, pH, and water quality parameters.

FWGWMP = Facility-wide Groundwater Monitoring Program
MNA = Monitored Natural Attenuation
PAH = Polycyclic Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
RVAAP = Ravenna Army Ammunition Plant
SVOC = Semivolatile Organic Compound
VOC = Volatile Organic Compound

Table 4-2. Wells Sampled and Chemical Groups Analyzed in Fall 2022

No.	RVAAP Area	Well ID	Aquifer	Metals	Explosives	Expanded Explosives (1)	VOCs	SVOCs (2)	PCBs	Pesticides	Cyanide	Nitrate	MNA Suite (3)	Other
1	RVAAP-04 Open Demolition Area #2	DETmw-003	Unconsolidated	X	X		X	X	X	X	X			-
2	RVAAP-04 Open Demolition Area #2	DETmw-004	Unconsolidated	X	X		X	X	X	X	X			-
3	RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	Unconsolidated			X							X	-
4	RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	Unconsolidated			X							X	-
5	RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	Unconsolidated		X	X								
6	RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	Unconsolidated		X	X								
7	RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	Unconsolidated		X	X								
8	RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	Unconsolidated			X							X	
9	RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	Upper Sharon		X	X								
10	RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	Upper Sharon		X	X								
11	RVAAP-08 Load Line 1	*LL1mw-063	Unconsolidated		X	X								
12	RVAAP-08 Load Line 1	LL1mw-064	Unconsolidated		X	X								
13	RVAAP-08 Load Line 1	LL1mw-080	Upper Sharon		X	X							X	-
14	RVAAP-08 Load Line 1	LL1mw-081	Upper Sharon		X									
15	RVAAP-08 Load Line 1	LL1mw-082	Upper Sharon		X	X								
16	RVAAP-08 Load Line 1	LL1mw-083	Upper Sharon		X	X							X	-
17	RVAAP-08 Load Line 1	LL1mw-084	Upper Sharon		X	X							X	-
18	RVAAP-08 Load Line 1	LL1mw-086	Unconsolidated		X	X								
19	RVAAP-08 Load Line 1	LL1mw-087	Unconsolidated		X	X								
20	RVAAP-08 Load Line 1	LL1mw-089	Unconsolidated		X	X								
21	RVAAP-09 Load Line 2	LL2mw-059	Upper Sharon		X	X							X	-
22	RVAAP-10 Load Line 3	LL3mw-237	Upper Sharon		X	X								
23	RVAAP-10 Load Line 3	LL3mw-238	Upper Sharon		X	X							X	-
24	RVAAP-10 Load Line 3	LL3mw-239	Upper Sharon		X	X							X	-
25	RVAAP-10 Load Line 3	LL3mw-241	Upper Sharon		X	X								
26	RVAAP-10 Load Line 3	LL3mw-245	Upper Sharon		X	X								
27	RVAAP-12 Load Line 12	LL12mw-185	Unconsolidated									X		Ammonia
28	RVAAP-12 Load Line 12	LL12mw-187	Unconsolidated									X		Ammonia
29	RVAAP-12 Load Line 12	LL12mw-244	Unconsolidated									X		Ammonia
30	RVAAP-12 Load Line 12	LL12mw-245	Unconsolidated									X		Ammonia
31	RVAAP-12 Load Line 12	LL12mw-246	Unconsolidated									X		Ammonia
32	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	Homewood Sandstone		X	X							X	
33	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	Homewood Sandstone		X	X								
34	RVAAP-43 Load Line 10	LL10mw-003	Homewood Sandstone				X[3]							
35	RVAAP-66 Facility-wide Groundwater	FWGmw-007	Unconsolidated		X									
36	RVAAP-66 Facility-wide Groundwater	FWGmw-010	Unconsolidated		X	X								
37	RVAAP-66 Facility-wide Groundwater	FWGmw-011	Unconsolidated		X									
38	RVAAP-66 Facility-wide Groundwater	FWGmw-012	Upper Sharon		X									
39	RVAAP-66 Facility-wide Groundwater	FWGmw-015	Unconsolidated		X									
40	RVAAP-66 Facility-wide Groundwater	FWGmw-016	Upper Sharon		X									
41	RVAAP-66 Facility-wide Groundwater	FWGmw-018	Basal Sharon									X		
42	RVAAP-66 Facility-wide Groundwater	FWGmw-020	Upper Sharon									X		
43	RVAAP-66 Facility-wide Groundwater	FWGmw-021	Upper Sharon		X									
44	RVAAP-66 Facility-wide Groundwater	FWGmw-023	Upper Sharon		X	X								

Table 4-2. Wells Sampled and Chemical Groups Analyzed in Fall 2022 (Continued)

No.	RVAAP Area	Well ID	Aquifer	Metals	Explosives	Expanded Explosives (1)	VOCs	SVOCs (2)	PCBs	Pesticides	Cyanide	Nitrate	MNA Suite (3)	Other
45	RVAAP-66 Facility-wide Groundwater	FWGmw-024	Upper Sharon		X									
46	RVAAP-66 Facility-wide Groundwater	SCFmw-004	Basal Sharon		X									

Monitoring well FWGmw-004 was supposed to be sampled for explosives. However, a hornet's nest prevented safe access to the well, and the well was not sampled. (Reference FCR LEIDOS_FWGW_012).
Monitoring well FBQmw-174 was supposed to be sampled for explosives, and the MNA suite. However, a sample was not collected in Fall 2022 due to the well being dry.
X = Indicates well or constituent to be sampled as part of the 2022 FWGWMP.
(1) Expanded explosives list includes 3,5-dinitroanaline, hexahydro-1,3,5-trinitroso-1,3,5-triazine, hexahydro-1,3-dinitroso-5-dinitro-1,3,5-triazine, hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine, 2,4-diamino-6-nitrotoluene, and 2,6-diamino-4-nitrotoluene.
(2) SVOCs include phthalates, nitroaromatics, polycyclic aromatic hydrocarbons, and phenols.
(3) MNA suite includes anions, total organic carbon, alkalinity, pH, and water quality parameters.

MNA = Monitored Natural Attenuation
PCB = Polychlorinated Biphenyl
RVAAP = Ravenna Army Ammunition Plant
SVOC = Semivolatile Organic Compound
VOC = Volatile Organic Compound

Table 4-3. Field Parameter Readings – Spring 2022 Sampling Event

RVAAP Area	Well ID	Date Sampled	Water Temperature (°C)	Conductivity (ms/cm)	pH (S.U.)	Turbidity (NTU)	Oxygen (mg/L)	Oxidation/Reduction Potential (mV)	Depth to Water (ft BTOC)
RVAAP-04 Open Demolition Area #2	DETmw-004	6/23/2022	15.29	0.74	6.39	4.48	0.4	97.6	11.9
RVAAP-04 Open Demolition Area #2	DETmw-003	6/23/2022	10.94	0.66	6.64	0.66	0.18	-46	9.3
RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	6/21/2022	17.15	0.23	5.61	1.28	0.16	234.7	10.74
RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	6/21/2022	13.66	0.53	6.87	1.76	0.06	194.2	4.68
RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	6/22/2022	12.41	0.48	7.24	9.43	4.6	75.5	12.35
RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	6/22/2022	13.45	0.5	6.96	17.28	3.97	221.8	14.28
RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	6/22/2022	16.23	0.5	7.27	13.66	0.04	-64.8	5.32
RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	6/22/2022	10.72	0.1	5.5	0	4.66	285.5	17.01
RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	6/21/2022	13.73	0.48	6.74	8.16	0.05	30.1	8.29
RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	6/21/2022	13.83	0.24	6.28	9.52	0.12	-24.4	10.7
RVAAP-08 Load Line 1	LL1mw-063	6/17/2022	15.57	0.24	4.67	8.57	7.66	356.1	22.92
RVAAP-08 Load Line 1	LL1mw-064	6/15/2022	13.87	0.35	7.71	85.84	0.04	-116.2	1.42
RVAAP-08 Load Line 1	LL1mw-087	6/16/2022	18.79	0.72	6.68	1.29	0.29	44.7	5.23
RVAAP-08 Load Line 1	LL1mw-080	6/23/2022	15.39	0.28	6.61	2.04	4.98	218.8	11.9
RVAAP-08 Load Line 1	LL1mw-086	6/24/2022	12.57	0.52	7.15	52.06	0.24	-91.1	7.97
RVAAP-08 Load Line 1	LL1mw-081	6/23/2022	14.16	0.36	5.99	9.42	8.74	21.6	29.39
RVAAP-08 Load Line 1	LL1mw-082	6/24/2022	13.44	0.25	6.15	9.19	0.35	-0.6	29.51
RVAAP-08 Load Line 1	LL1mw-083	6/17/2022	12.9	0.26	4.17	1.11	3.14	338.1	31.3
RVAAP-08 Load Line 1	LL1mw-089	6/14/2022	11.69	0.08	4.55	5.25	1.79	252.8	22.59
RVAAP-08 Load Line 1	LL1mw-084	6/17/2022	16.72	0.33	5.58	1.43	4.04	253.1	28.1
RVAAP-09 Load Line 2	LL2mw-059	6/23/2022	13.12	0.96	6.42	6.39	3.13	274.9	12.87
RVAAP-10 Load Line 3	LL3mw-238	6/24/2022	19.15	0.38	6.1	9.02	3.27	181.6	18
RVAAP-10 Load Line 3	LL3mw-237	6/24/2022	14.78	0.33	6.14	2.98	3.92	278.1	16.48
RVAAP-10 Load Line 3	LL3mw-239	6/24/2022	17.82	0.19	5.94	7.97	0.67	134.1	25.4
RVAAP-10 Load Line 3	LL3mw-241	6/24/2022	12.88	0.2	5.76	6.1	3.78	300.5	12.6
RVAAP-10 Load Line 3	LL3mw-245	6/27/2022	13.54	0.75	7.02	8.43	0.15	48.6	12.7
RVAAP-12 Load Line 12	LL12mw-187	6/28/2022	11.62	12.08	6.2	4.63	0.05	273.7	10.37
RVAAP-12 Load Line 12	LL12mw-185	6/27/2022	21.85	3.93	6.61	5.08	0.45	246.3	9.45
RVAAP-12 Load Line 12	LL12mw-244	6/27/2022	15.64	0.48	7.38	0.69	0.17	-59.4	14.61
RVAAP-12 Load Line 12	LL12mw-245	6/27/2022	21.86	1.17	6.93	4.86	0.45	19.8	11.4
RVAAP-12 Load Line 12	LL12mw-246	6/27/2022	12.6	0.93	6.8	5.35	0.26	-28.3	17.06
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	6/28/2022	11.75	0.12	5.02	0.77	0.98	109.2	43.76
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-174	6/28/2022	16.07	0.15	4.88	5.89	7.76	242.7	19.69
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	6/28/2022	13.1	0.07	5.68	8.1	9.58	243.3	17.89
RVAAP-43 Load Line 10	LL10mw-003	6/28/2022	12.69	0.35	6.73	0.36	1.98	97.1	21.19
RVAAP-66 Facility-wide Groundwater	SCFmw-004	6/16/2022	12.71	0.96	7.63	1.22	1.15	-10.7	0
RVAAP-66 Facility-wide Groundwater	FWGmw-007	6/28/2022	13.91	0.7	7.25	8.9	1.22	211.9	23.85
RVAAP-66 Facility-wide Groundwater	FWGmw-020	6/16/2022	14.91	0.73	6.79	7.87	0.64	-36.9	21.12
RVAAP-66 Facility-wide Groundwater	FWGmw-016	6/16/2022	15.02	0.7	6.65	0.5	0.78	-22.2	17.25
RVAAP-66 Facility-wide Groundwater	FWGmw-015	6/16/2022	19.24	2.4	-	9.53	1	180.1	8.9
RVAAP-66 Facility-wide Groundwater	FWGmw-004	6/22/2022	16.6	0.72	6.83	1.5	0.35	202.4	14.4
RVAAP-66 Facility-wide Groundwater	FWGmw-018	6/16/2022	11.99	0.62	6.76	1	0.14	-56.5	21.35
RVAAP-66 Facility-wide Groundwater	FWGmw-023	6/28/2022	11.08	0.6	6.94	0	0.49	-83.6	116.85
RVAAP-66 Facility-wide Groundwater	FWGmw-024	6/16/2022	12.3	0.48	6.78	7.99	0.1	-16.1	13.04
RVAAP-66 Facility-wide Groundwater	FWGmw-010	6/14/2022	15.68	0.04	4.5	6.18	7.39	302.4	10.85
RVAAP-66 Facility-wide Groundwater	FWGmw-012	6/17/2022	13.4	0.19	5.22	7.92	0.04	129.2	1.57

Table 4-3. Field Parameter Readings – Spring 2022 Sampling Event (Continued)

RVAAP Area	Well ID	Date Sampled	Water Temperature (°C)	Conductivity (ms/cm)	pH (S.U.)	Turbidity (NTU)	Oxygen (mg/L)	Oxidation/Reduction Potential (mV)	Depth to Water (ft BTOC)
RVAAP-66 Facility-wide Groundwater	FWGmw-011	6/17/2022	12.19	0.34	7.13	17.74	0.07	-92.8	3.82
RVAAP-66 Facility-wide Groundwater	FWGmw-021	6/16/2022	11.89	0.17	5.86	8.2	0.65	88.9	20.83

°C = Degrees Celsius
BTOC = Below Top of Casing
ft = Foot
mg/L = Milligrams per Liter
mS/cm MilliSiemens per Centimeter
mV = Millivolt
ID = Identifier
NTU = Nephelometric Turbidity Unit
RVAAP = Ravenna Army Ammunition Plant
S.U. = Standard Unit

Table 4-4. Field Parameter Readings – Fall 2022 Sampling Event

RVAAP Area	Well ID	Date Sampled	Water Temperature (°C)	Conductivity (mS/cm)	pH (S.U.)	Turbidity (NTU)	Oxygen (mg/L)	Oxidation/Reduction Potential (mV)	Depth to Water (ft BTOC)
RVAAP-04 Open Demolition Area #2	DETmw-004	10/5/2022	12.07	0.76	6.61	0.88	2.1	187.9	N/A
RVAAP-04 Open Demolition Area #2	DETmw-003	10/5/2022	13.34	0.66	7.1	0.35	0.16	-66	9.43
RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	10/3/2022	13.53	0.5	7.1	18.7	0.05	-55.7	6.61
RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	10/3/2022	13.08	0.23	7.01	9.92	0.22	-72.7	12.9
RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	9/30/2022	12.34	0.47	7.29	9.52	0.22	-35.2	9.53
RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	10/3/2022	12.09	0.52	7.23	9.23	1.31	228	16.05
RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	9/30/2022	13	0.46	7.18	8.23	0.1	30.8	14.08
RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	9/30/2022	13.64	0.52	7.35	5.38	0.16	81.8	6.48
RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	10/5/2022	12.63	0.11	5.71	4.55	5.89	203.2	20.78
RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	9/30/2022	14.35	0.59	7.02	1.54	0.6	181.9	13.08
RVAAP-08 Load Line 1	LL1mw-063[a]	9/28/2022	-	-	-	-	-	-	N/A
RVAAP-08 Load Line 1	LL1mw-086	9/29/2022	12.22	0.48	7.54	60.51	0.21	-115.2	10.68
RVAAP-08 Load Line 1	LL1mw-082	10/3/2022	16.99	0.38	6.67	27.14	4.24	-23.6	37.88
RVAAP-08 Load Line 1	LL1mw-081	9/27/2022	12.83	0.36	6.68	9.92	0.28	3.4	33.75
RVAAP-08 Load Line 1	LL1mw-064	9/29/2022	13.45	0.35	7.7	4.3	0.09	-117.2	4.06
RVAAP-08 Load Line 1	LL1mw-087	9/27/2022	14.26	1.15	6.78	3.17	0.4	72.7	N/A
RVAAP-08 Load Line 1	LL1mw-080	9/28/2022	15.45	1.41	6.41	3.05	1.11	199.6	18.2
RVAAP-08 Load Line 1	LL1mw-089	9/28/2022	11.43	0.07	5.1	1.5	1.39	235.9	26.15
RVAAP-08 Load Line 1	LL1mw-084	9/27/2022	12.23	0.32	5.69	0.21	3.39	267.1	N/A
RVAAP-08 Load Line 1	LL1mw-083	9/27/2022	11.26	0.27	4.41	0.11	5.73	354.7	34.81
RVAAP-09 Load Line 2	LL2mw-059	9/29/2022	13.63	0.27	6.11	131.09	0.35	139.3	14.92
RVAAP-10 Load Line 3	LL3mw-238	9/29/2022	14.4	0.37	6.73	9.55	3.91	193.6	20.16
RVAAP-10 Load Line 3	LL3mw-245	10/5/2022	10.83	0.82	6.93	6.01	0.06	-42.9	15.95
RVAAP-10 Load Line 3	LL3mw-239	9/29/2022	11.99	0.2	5.7	4.37	1.68	154.6	30.97
RVAAP-10 Load Line 3	LL3mw-237	9/29/2022	13.79	0.29	6.27	1.51	0.46	133.3	21.99
RVAAP-10 Load Line 3	LL3mw-241	9/29/2022	13.49	0.19	6.19	0.49	0.99	210	18
RVAAP-12 Load Line 12	LL12mw-244	9/30/2022	15.8	0.56	7.15	3,258.20	0.01	-0.2	17.84
RVAAP-12 Load Line 12	LL12mw-245	9/30/2022	13.94	1.22	6.88	642.36	2.31	6.8	18.15
RVAAP-12 Load Line 12	LL12mw-246	10/5/2022	11.03	0.89	7.08	5.99	0.66	-45.3	16.62
RVAAP-12 Load Line 12	LL12mw-187	9/30/2022	11.1	13	6.37	2.24	0.06	252.7	15.06
RVAAP-12 Load Line 12	LL12mw-185	9/30/2022	12.89	4.37	6.68	0.42	0.16	238.5	12.96
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-174[b]	-	-	-	-	-	-	-	-
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	10/4/2022	12.61	0.08	5.59	1.8	9.25	194.2	20.23
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	10/4/2022	10.9	0.12	5.62	0.09	0.33	18.9	45.73
RVAAP-43 Load Line 10	LL10mw-003	10/4/2022	13.83	0.38	6.64	7.9	1.68	212.4	21.9
RVAAP-66 Facility-wide Groundwater	FWGmw-011	9/28/2022	13.37	0.32	7.26	33.9	1.08	-85.2	4.86
RVAAP-66 Facility-wide Groundwater	FWGmw-021	10/4/2022	10.91	0.18	6.32	21.98	0.24	69	24.45
RVAAP-66 Facility-wide Groundwater	FWGmw-007	10/3/2022	17.44	0.97	7.12	9.93	1	77.7	24.84
RVAAP-66 Facility-wide Groundwater	FWGmw-024	10/4/2022	12.57	0.48	7.42	8.78	0.13	-35.9	14.84
RVAAP-66 Facility-wide Groundwater	FWGmw-010	9/28/2022	14.77	0.05	5.08	8.15	6.23	257.2	14.28
RVAAP-66 Facility-wide Groundwater	FWGmw-012	9/28/2022	11.35	0.19	6	6.32	0.06	89	4.08
RVAAP-66 Facility-wide Groundwater	FWGmw-020	10/4/2022	11	0.8	7.2	5.65	1.32	-94.2	24.27
RVAAP-66 Facility-wide Groundwater	FWGmw-015	10/3/2022	20.1	2.16	6.79	5.63	2.4	89.5	11.09
RVAAP-66 Facility-wide Groundwater	FWGmw-016	9/27/2022	13.89	0.7	7.01	1.19	0.64	-47.5	18.85
RVAAP-66 Facility-wide Groundwater	FWGmw-023	10/4/2022	12.17	0.67	7.28	0.28	1.12	-65.6	118.27

Table 4-4. Field Parameter Readings – Fall 2022 Sampling Event (Continued)

RVAAP Area	Well ID	Date Sampled	Water Temperature (°C)	Conductivity (mS/cm)	pH (S.U.)	Turbidity (NTU)	Oxygen (mg/L)	Oxidation/Reduction Potential (mV)	Depth to Water (ft BTOC)
RVAAP-66 Facility-wide Groundwater	FWGmw-018	10/4/2022	11.24	0.65	7.44	0	0.22	-138.2	23.73
RVAAP-66 Facility-wide Groundwater	SCFmw-004	9/30/2022	11.76	1.1	7	0	0.11	-112.8	1.6

[a]Sample collected over the course of a few days due to well going dry.
[b]No sample collected due to well being dry.

°C = Degrees Celsius
BTOC = Below Top of Casing
ft = Feet
ID = Identifier
mg/L = Milligrams per Liter
mS/cm = Millisiemens per Centimeter
mV = Millivolt
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
RVAAP = Ravenna Army Ammunition Plant
S.U. = Standard Unit

Table 4-5. 2022 Summary Statistics of Field Parameters and Chemical Analysis

Location	Analysis Type	Analyte	Units	CAS Number	Results >Detection Limit	Minimum Detect	Maximum Detect	Average Result	GW Screening Level	GW Screening Level Source	Number Exceeding GW Screening Level	Station at Max Detect	Date Collected at Max Detect
Basal Sharon Conglomerate	Field Measurements	Conductivity	mS/cm	N237	2/2	0.62	1.1	0.833			0	SCFmw-004	09/30/22
Basal Sharon Conglomerate	Field Measurements	Depth to Water	ft BTOC	WDEPTH	2/2	0	23.73	11.67			0	FWGmw-018	10/04/22
Basal Sharon Conglomerate	Field Measurements	ORP	mV	ORP	2/2	-138.2	-10.7	-79.55			0	SCFmw-004	06/16/22
Basal Sharon Conglomerate	Field Measurements	Oxygen	mg/L	17778-80-2	2/2	0.11	1.15	0.405			0	SCFmw-004	06/16/22
Basal Sharon Conglomerate	Field Measurements	Turbidity	NTU	TURBID	2/2	0	1.22	0.56			0	SCFmw-004	06/16/22
Basal Sharon Conglomerate	Field Measurements	Water Temperature	°C	WTEMP	2/2	11.24	12.71	11.93			0	SCFmw-004	06/16/22
Basal Sharon Conglomerate	Field Measurements	pH	units	N704	2/2	6.76	7.63	7.21			0	FWGmw-018	10/04/22
Homewood	Field Measurements	Conductivity	mS/cm	N237	7/7	0.07	0.38	0.18			0	LL10mw-003	10/04/22
Homewood	Field Measurements	Depth to Water	ft BTOC	WDEPTH	6/6	17.89	45.73	27.20			0	FBQmw-173	10/04/22
Homewood	Field Measurements	ORP	mV	ORP	7/7	18.9	243.3	159.69			0	FBQmw-175	06/28/22
Homewood	Field Measurements	Oxygen	mg/L	17778-80-2	7/7	0.33	9.58	4.51			0	FBQmw-175	06/28/22
Homewood	Field Measurements	Turbidity	NTU	TURBID	7/7	0.09	8.10	3.56			0	FBQmw-175	06/28/22
Homewood	Field Measurements	Water Temperature	°C	WTEMP	7/7	10.9	16.07	12.99			0	FBQmw-174	06/28/22
Homewood	Field Measurements	pH	units	N704	7/7	4.88	6.73	5.74			0	LL10mw-003	06/28/22
Homewood	Anions	Nitrate	mg/L	14797-55-8	1/3	0.15	0.94	0.43	10	MCL	0	FBQmw-174	06/28/22
Homewood	Anions	Nitrite	mg/L	14797-65-0	2/3	0.07	0.1	0.09	1	MCL	0	FBQmw-173	10/04/22
Homewood	Anions	Sulfate	mg/L	14808-79-8	3/3	33	55	41			0	FBQmw-174	06/28/22
Homewood	Miscellaneous	Alkalinity	mg/L	N33	3/3	10	34	22.33			0	FBQmw-173	10/04/22
Homewood	Miscellaneous	TOC	mg/L	N997	3/3	0.44	1.7	1.0			0	FBQmw-174	06/28/22
Homewood	Explosives/Propellants	TNT	µg/L	118-96-7	1/5	0.11	5.6	1.21	0.98	RSL	1	FBQmw-174	06/28/22
Homewood	Explosives/Propellants	2,4-DNT	µg/L	121-14-2	1/5	0.085	0.37	0.1438	0.24	RSL	1	FBQmw-174	06/28/22
Homewood	Explosives/Propellants	2-Amino-4,6-DNT	µg/L	35572-78-2	1/5	0.11	8.7	1.83	3.9	RSL	1	FBQmw-174	06/28/22
Homewood	Explosives/Propellants	3,5-Dinitroaniline	µg/L	618-87-1	1/5	0.32	0.86	0.434			0	FBQmw-174	06/28/22
Homewood	Explosives/Propellants	4-Amino-2,6-DNT	µg/L	19406-51-0	1/5	0.13	17	2.506	3.9	RSL	2	FBQmw-174	06/28/22
Homewood	VOCs	Carbon tetrachloride	µg/L	56-23-5	2/2	2.9	4	3.45	5	MCL	0	LL10mw-003	06/28/22
Unconsolidated	Field Measurements	Conductivity	mS/cm	N237	19/19	0.17	1.41	0.434			0	LL1mw-080	09/28/22
Unconsolidated	Field Measurements	Depth to Water	ft BTOC	WDEPTH	19/19	1.57	118.27	23.99			0	FWGmw-023	10/04/22
Unconsolidated	Field Measurements	ORP	mV	ORP	19/19	-94.2	354.7	92.36			0	LL1mw-083	09/27/22
Unconsolidated	Field Measurements	Oxygen	mg/L	17778-80-2	19/19	0.04	8.74	1.72			0	LL1mw-081	06/23/22
Unconsolidated	Field Measurements	Turbidity	NTU	TURBID	19/19	0	131.09	9.77			0	LL2mw-059	09/29/22
Unconsolidated	Field Measurements	Water Temperature	°C	WTEMP	19/19	10.83	19.15	13.53			0	LL3mw-238	06/24/22
Unconsolidated	Field Measurements	pH	units	N704	19/19	4.17	7.42	6.33			0	FWGmw-024	10/04/22
Unconsolidated	Metals, Total	Aluminum	mg/L	7429-90-5	3/6	0.019	0.07	0.046	2	RSL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Antimony	mg/L	7440-36-0	0/6	0.001	0.001	0.001	0.006	MCL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Arsenic	mg/L	7440-38-2	4/6	0.001	0.012	0.0073	0.01	MCL	2	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Barium	mg/L	7440-39-3	6/6	0.045	0.066	0.052	2	MCL	0	DETmw-004	10/05/22
Unconsolidated	Metals, Total	Beryllium	mg/L	7440-41-7	4/6	0.000086	0.0003	0.000237	0.004	MCL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Calcium	mg/L	7440-70-2	6/6	92	130	105			0	DETmw-004	10/05/22
Unconsolidated	Metals, Total	Cobalt	mg/L	7440-48-4	3/6	0.0002	0.00055	0.000335	0.0208	RC	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Copper	mg/L	7440-50-8	2/6	0.00073	0.0018	0.001505	1.3	MCL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Iron	mg/L	7439-89-6	5/6	0.059	1.9	1.29	1.91	BKG	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Magnesium	mg/L	7439-95-4	6/6	26	35	31.83			0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Manganese	mg/L	7439-96-5	6/6	0.042	0.25	0.20	0.075	BKG	5	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Nickel	mg/L	7440-02-0	1/6	0.00041	0.001	0.000902	0.039	RSL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Potassium	mg/L	7440-09-7	6/6	1.1	2.4	1.85			0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Silver	mg/L	7440-22-4	1/6	0.000033	0.0001	0.0000883	0.0094	RSL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Sodium	mg/L	7440-23-5	6/6	1.9	13	9.73			0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Thallium	mg/L	7440-28-0	3/6	0.00011	0.0003	0.000187	0.002	MCL	0	DETmw-003	10/05/22
Unconsolidated	Metals, Total	Zinc	mg/L	7440-66-6	2/6	0.008	0.032	0.0127	0.6	RSL	0	DETmw-004	10/05/22
Unconsolidated	Anions	Nitrate	mg/L	14797-55-8	6/18	0.2	1600	311.79	10	MCL	5	LL12mw-187	09/30/22

Table 4-5. 2022 Summary Statistics of Field Parameters and Chemical Analysis (Continued)

Location	Analysis Type	Analyte	Units	CAS Number	Results >Detection Limit	Minimum Detect	Maximum Detect	Average Result	GW Screening Level	GW Screening Level Source	Number Exceeding GW Screening Level	Station at Max Detect	Date Collected at Max Detect
Unconsolidated	Anions	Sulfate	mg/L	14808-79-8	6/6	9.9	28	18.32			0	WBGmw-006	06/21/22
Unconsolidated	Anions	Sulfide	mg/L	18496-25-8	0/6	2	2	2			0	WBGmw-018	10/05/22
Unconsolidated	Miscellaneous	Alkalinity	mg/L	N33	6/6	46	320	178.67			0	WBGmw-009	09/30/22
Unconsolidated	Miscellaneous	Ammonia	mg/L	7664-41-7	11/12	0.039	660	108.48			0	LL12mw-187	06/28/22
Unconsolidated	Miscellaneous	TOC	mg/L	N997	6/6	0.79	1.8	1.265			0	WBGmw-018	06/22/22
Unconsolidated	Explosives/Propellants	2-Amino-4,6-DNT	µg/L	35572-78-2	1/40	0.1	2.2	0.162	3.9	RSL	0	LL1mw-086	06/24/22
Unconsolidated	Explosives/Propellants	4-Amino-2,6-DNT	µg/L	19406-51-0	1/40	0.12	2.4	0.192	3.9	RSL	0	LL1mw-086	06/24/22
Unconsolidated	Explosives/Propellants	DNX	µg/L	80251-29-2	0/28	0.26	0.28	0.269			0	WBGmw-009	09/30/22
Unconsolidated	Explosives/Propellants	HMX	µg/L	2691-41-0	8/40	0.21	53.3	0.564	100	RSL	0	WBGmw-006	09/30/22
Unconsolidated	Explosives/Propellants	MNX	µg/L	5755-27-1	2/28	0.3	0.49	0.319			0	WBGmw-006	09/30/22
Unconsolidated	Explosives/Propellants	RDX	µg/L	121-82-4	9/40	0.15	7.2	0.699	0.97	RSL	5	WBGmw-006	09/30/22
Unconsolidated	VOCs	Benzene	µg/L	71-43-2	0/6	0.4	0.8	0.6	5	MCL	0	DETmw-003	10/05/22
Unconsolidated	VOCs	Ethylbenzene	µg/L	100-41-4	0/6	0.4	0.4	0.4	700	MCL	0	DETmw-003	10/05/22
Upper Sharon	Field Measurements	Conductivity	mS/cm	N237	19/19	0.17	1.41	0.434			0	LL1mw-080	09/28/22
Upper Sharon	Field Measurements	Depth to Water	ft BTOC	WDEPTH	19/19	1.57	118.27	23.99			0	FWGmw-023	10/04/22
Upper Sharon	Field Measurements	ORP	mV	ORP	19/19	-94.2	354.7	92.36			0	LL1mw-083	09/27/22
Upper Sharon	Field Measurements	Oxygen	mg/L	17778-80-2	19/19	0.04	8.74	1.72			0	LL1mw-081	06/23/22
Upper Sharon	Field Measurements	Turbidity	NTU	TURBID	19/19	0	131.09	9.77			0	LL2mw-059	09/29/22
Upper Sharon	Field Measurements	Water Temperature	°C	WTEMP	19/19	10.83	19.15	13.53			0	LL3mw-238	06/24/22
Upper Sharon	Field Measurements	pH	units	N704	19/19	4.17	7.42	6.33			0	FWGmw-024	10/04/22
Upper Sharon	Anions	Nitrate	mg/L	14797-55-8	14/16	0.098	0.81	0.376	10	MCL	0	LL2mw-059	06/23/22
Upper Sharon	Anions	Sulfate	mg/L	14808-79-8	14/14	19	360	116.71			0	LL1mw-080	09/28/22
Upper Sharon	Anions	Sulfide	mg/L	18496-25-8	0/8	2	2	2			0	LL3mw-238	09/29/22
Upper Sharon	Miscellaneous	Alkalinity	mg/L	N33	12/14	6.4	160	81.77			0	LL3mw-238	06/24/22
Upper Sharon	Miscellaneous	TOC	mg/L	N997	8/13	0.57	2.9	1.18			0	LL3mw-238	06/24/22
Upper Sharon	Explosives/Propellants	1,3,5-Trinitrobenzene	µg/L	99-35-4	9/38	0.21	14	1.24	59	RSL	0	LL3mw-237	06/24/22
Upper Sharon	Explosives/Propellants	1,3-DNB	µg/L	99-65-0	0/38	0.1	0.12	0.11	0.2	RSL	0	FWGmw-023	10/04/22
Upper Sharon	Explosives/Propellants	TNT	µg/L	118-96-7	12/38	0.1	42	2.345	0.98	RSL	8	LL3mw-237	06/24/22
Upper Sharon	Explosives/Propellants	2,4-Diamino-6-nitrotoluene	µg/L	6629-29-4	0/28	0.94	1.1	0.984			0	FWGmw-023	10/04/22
Upper Sharon	Explosives/Propellants	2,4-DNT	µg/L	121-14-2	6/38	0.083	2.9	0.61	0.24	RSL	5	LL1mw-083	09/27/22
Upper Sharon	Explosives/Propellants	2,6-Diamino-4-nitrotoluene	µg/L	59229-75-3	0/28	0.94	1.1	0.984			0	FWGmw-023	10/04/22
Upper Sharon	Explosives/Propellants	2,6-DNT	µg/L	606-20-2	2/38	0.083	1.7	0.154	0.122	RA	2	LL1mw-083	09/27/22
Upper Sharon	Explosives/Propellants	2-Amino-4,6-DNT	µg/L	35572-78-2	14/38	0.1	9.6	1.62	3.9	RSL	6	LL1mw-083	09/27/22
Upper Sharon	Explosives/Propellants	3,5-Dinitroaniline	µg/L	618-87-1	14/31	0.27	2.7	0.713			0	LL1mw-084	09/27/22
Upper Sharon	Explosives/Propellants	4-Amino-2,6-DNT	µg/L	19406-51-0	15/38	0.13	28	4.66	3.9	RSL	9	LL3mw-238	01/05/22
Upper Sharon	Explosives/Propellants	HMX	µg/L	2691-41-0	6/38	0.21	4.4	0.519	100	RSL	0	LL1mw-080	06/23/22
Upper Sharon	Explosives/Propellants	MNX	µg/L	5755-27-1	1/22	0.3	3.3	0.434			0	LL3mw-237	06/24/22
Upper Sharon	Explosives/Propellants	RDX	µg/L	121-82-4	6/38	0.18	26	1.171	0.97	RSL	4	LL1mw-080	06/23/22
Upper Sharon	Explosives/Propellants	TNX	µg/L	13980-04-6	0/28	0.26	2.9	0.366			0	LL3mw-237	06/24/22

µg/L = Micrograms per Liter
BKG = Background Screening Level
BTOC = Below Top of Casing
°C = Degrees Celsius
CAS = Chemical Abstracts Service
DNB = Dinitrobenzene
DNT = Dinitrotoluene
DNX = Hexahydro-1,3-Dinitroso-5-Dinitro-1,3,5-Triazine
ft = feet
GW = Groundwater
HMX = Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
MNX = Hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-Triazine
mS/cm = Millisiemens per Centimeter
mV = Millivolt
NTU = Nephelometric Turbidity Unit
ORP = Oxidation-Reduction Potential
RA = Resident Adult
RC = Resident Child
RDX = Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RSL = Regional Screening Level
TNT = 2,4,6-Trinitrotoluene
TNX = Hexahydro-1,3,5-Trinitroso-1,3,5-Triazine
TOC = Total Organic Carbon
VOC = Volatile Organic Compound

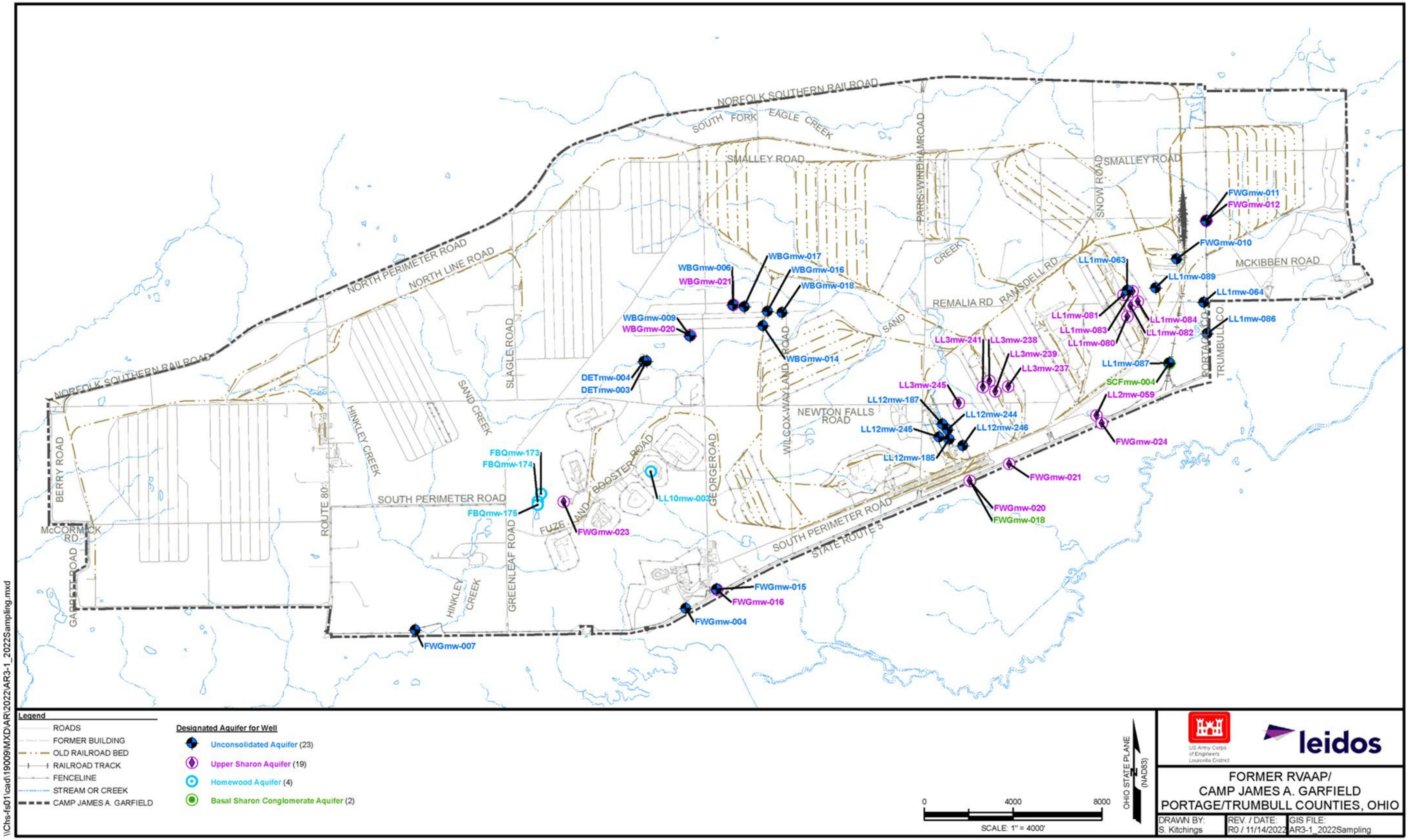


Figure 4-1. FWGWMP Wells Sampled in 2022

THIS PAGE INTENTIONALLY LEFT BLANK.

5.0 GROUNDWATER ELEVATIONS

This section discusses the process for obtaining groundwater elevations in 2022, presents updated potentiometric surfaces for the four aquifers at CJAG, and compares and contrasts the current potentiometric surfaces with previous surfaces.

5.1 GROUNDWATER ELEVATION MONITORING

Annual water level measurements were collected in October 2022 in accordance with procedures in Section 5.4.3.1 of the Facility-wide Sampling and Analysis Plan (FWSAP) (SAIC 2011) and the RIWP (TEC-Weston 2016). Table 5-1 presents the water level measurements at each well.

During the field activities, groundwater level measurements could not be obtained from 14 wells (BKGmw-015, BKGmw-021, DETmw-004, LL1mw-063, LL1mw-085, LL1mw-087, LL6-mw-002, LL6mw-006, LL6mw-008, LL12mw-189, RQLmw-017, SCLmw-001, SCLmw-002, and SCLmw-003) due to the top of the permanent pump being above the groundwater level. The groundwater level measurements were not obtained from DA2mw-106, DA2mw-112, and FWGmw-004 due to active bee's nests. Obstacles in the following wells (LL1mw-065, LL1mw-084, LL3mw-237, LL3mw-238, and LL3mw-241) were encountered and no groundwater measurement was recorded. Well LL3mw-235 was dry during the October 2022 event. Therefore, groundwater elevations from 297 FWGWMP monitoring wells were used to generate the potentiometric surfaces presented in Figures 5-1 through 5-4. These figures show potentiometric surfaces for the Unconsolidated, Homewood Sandstone, Upper Sharon Sandstone, and Basal Sharon Conglomerate aquifers. These depictions include topographic and groundwater elevations to infer potentiometric surfaces near surface water features; however, staff gauges in surface water bodies are not available. Therefore, the interpretations represent estimates based on available information. The remainder of this section discusses the hydraulic gradients and inferred groundwater flow directions in each of the aquifers, vertical and horizontal gradients, and potential offsite migration pathways.

5.2 HORIZONTAL GRADIENTS AND FLOW VELOCITIES

5.2.1 Unconsolidated Aquifer

Figure 5-1 illustrates the potentiometric surface of the Unconsolidated aquifer. The site-wide hydraulic gradient in the Unconsolidated aquifer generally indicates an easterly component, but a local variation shows a southwesterly flow component along the southwestern section of the facility. Variations in gradient direction are associated with the influence of topography, streams and waterbodies, land use, subsurface heterogeneity, and presence/absence of unconsolidated materials. In many portions of the site, streams likely serve as discharge locations for the Unconsolidated aquifer.

Where the Unconsolidated aquifer is absent due to erosion or insufficient thickness, the Homewood formation or Sharon Sandstone is the uppermost aquifer, as shown with a hatched pattern in Figure 5-1. The Homewood formation and Sharon Sandstone are in direct hydraulic communication with the Unconsolidated aquifer, where present.

Horizontal hydraulic gradients, ranging from 0.008 to 0.019 ft/ft, were calculated for the Unconsolidated aquifer at the three locations shown in Figure 5-1. The average linear groundwater velocity (seepage velocity) was calculated using the three gradients, average porosity values (EQM 2012) from previous Shelby tube samples, and average hydraulic conductivity values derived from rising head/falling head tests conducted on 10 wells in November 2012 (TEC-Weston 2018). The calculated velocities (0.035, 0.049, and 0.084 ft/day) correspond to approximately 13, 18, and 31 ft/yr. Table 5-2 summarizes the horizontal hydraulic gradient and average linear groundwater velocity data for the various aquifers using the October 2022 groundwater elevation measurement data.

5.2.2 Homewood Sandstone Aquifer

Figure 5-2 illustrates the potentiometric surface of the Homewood formation. The hydraulic gradient within the Homewood formation varies across CJAG. The gradient near C Block Quarry trends south to east, the gradient near Fuze and Booster Quarry is generally eastward, and the gradient near Load Lines 9 and 10 forms a radial pattern around a topographic high point.

Horizontal hydraulic gradients were calculated for the Homewood Sandstone aquifer at the four locations shown in Figure 5-2. The gradients are 0.007 ft/ft. Seepage velocities were calculated using the four gradients, average porosity values from previous core samples (EQM 2012), and average hydraulic conductivity values derived from hydraulic testing (slug testing) conducted on two Homewood Sandstone aquifer wells (TEC-Weston 2018). The calculated seepage velocities (0.229, 0.229, 0.229, and 0.860 ft/day) correspond to velocities between 84 and 314 ft/yr, as shown in Table 5-2.

5.2.3 Upper Sharon Aquifer

Figure 5-3 presents the potentiometric surface of the Sharon Sandstone aquifer (also referred to as the Upper Sharon). The site-wide hydraulic gradient in the Upper Sharon generally has a northeasterly component, but local variations include radial, northerly, and/or southerly flow components. Notable features of the potentiometric surface include a groundwater divide in the central portion of CJAG with gradients north of the divide trending northeast and gradients south of the divide trending southeast. In addition, a radial pattern is noted along the topographic high point near Load Line 2.

As stated above, the Upper Sharon is in direct hydraulic communication with the Unconsolidated aquifer for much of its extent in the central and eastern portions of CJAG. It is inferred that where streams have eroded the unconsolidated deposits, the Upper Sharon is in direct hydraulic communication with the local stream system. Portions of these streams likely receive groundwater discharge from the Upper Sharon.

Horizontal hydraulic gradients were calculated for the Sharon Sandstone aquifer at the three locations shown in Figure 5-3. The gradients range from 0.014 to 0.023 ft/ft. Seepage velocities were calculated using the three gradients, average porosity values from previous core samples (EQM 2012), and average hydraulic conductivity values derived from hydraulic testing (slug testing) conducted on two Sharon Sandstone aquifer wells (TEC-Weston 2018). The calculated seepage velocities (1.685, 2.046, and 2.769 ft/day) correspond to approximately or 615, 747, and 1,011 ft/yr, as listed in Table 5-2.

5.2.4 Basal Sharon Conglomerate Aquifer

The deepest aquifer zone monitored at CJAG is the Basal Sharon Conglomerate, which occurs within the lower portions of the Sandstone/Conglomerate unit of the Sharon Member. The hydraulic gradient in the Basal Sharon Conglomerate is generally eastward with local trends to the northeast, as illustrated in Figure 5-4.

Horizontal hydraulic gradients were calculated for the Basal Sharon Conglomerate at the three locations shown in Figure 5-4. The gradients range from 0.004 to 0.006 ft/ft. Seepage velocities were calculated using the three gradients, porosity values obtained from previous cores in the Upper Sharon (EQM 2012), and hydraulic conductivity value obtained from literary sources for sandstone formations (Bear 1972). The calculated seepage velocities (0.011 and 0.016 ft/day) correspond to approximately 4 and 6 ft/yr, as listed in Table 5-2.

5.3 VERTICAL GRADIENTS

Groundwater elevations at 13 clustered well pairs were compared to calculate vertical gradients between CJAG aquifers. For this evaluation, a well cluster is defined as two wells located within 20 feet of one another and screened in different aquifers. Figure 5-5 presents locations of the well clusters within CJAG.

Table 5-3 lists the well clusters evaluated along with the October 2022 groundwater elevations, midpoint elevation of each well screen interval, and calculated vertical hydraulic gradients. The vertical gradient at a well cluster was calculated as the quotient of the change in groundwater elevations (head) and vertical distance between screen midpoints. A negative vertical gradient indicates an upward gradient, and a positive vertical gradient indicates a downward gradient.

5.3.1 Unconsolidated and Homewood Aquifers

A vertical hydraulic gradient between the Unconsolidated and Homewood aquifers was not calculated for the October 2022 sampling event. A groundwater elevation could not be obtained for well LL6mw-008 due to the water level being below the top of the pump, which is used along with LL6mw-009 to calculate a vertical gradient.

5.3.2 Unconsolidated and Upper Sharon Aquifers

Seven well clusters screened in the Unconsolidated and Upper Sharon aquifers were evaluated to determine the vertical hydraulic gradient between the aquifers. Two of the seven well clusters (EBGmw125/EBGmw-131 and WBGmw-018/WBFmw-019) displayed an upward vertical gradient of -0.028 and -0.047 ft/ft, respectively, from the Upper Sharon to the Unconsolidated aquifer. The observed gradient indicates the Upper Sharon aquifer may be under confined or semi-confined conditions in these areas.

The five remaining well clusters exhibited a downward vertical gradient from the Unconsolidated aquifer toward the Upper Sharon aquifer. The downward gradients ranged from 0.037 to 0.287 ft/ft. At the two well clusters (FWGmw-015/FWGmw-016 and NTAmw-113/NTAmw-120) with the largest vertical gradient, a shale layer is present between the Unconsolidated aquifer and the Upper Sharon Sandstone, as evidenced in the boring logs. The gradient observed at these locations is likely attributable to the shale acting as an aquitard; however, the shale is limited in areal extent. At the remaining three locations, the downward gradient has a lower magnitude but still likely indicates the presence of a low permeable layer between the two aquifers.

5.3.3 Unconsolidated and Basal Sharon Conglomerate Aquifers

Groundwater elevations in two well clusters (LL1mw-087/SCFmw-004 and LL12mw-247/SCFmw-002) were evaluated to estimate the vertical hydraulic gradient between the Unconsolidated and the Basal Sharon Conglomerate aquifers. As listed in Table 5-3, the LL1mw-087/SCFmw-004 cluster exhibits an upward gradient of approximately -0.033 ft/ft, while the LL12mw-247/SCFmw-002 cluster exhibits a downward gradient of approximately 0.127 ft/ft.

The LL1mw-087/SCFmw-004 cluster is in the eastern portion of CJAG, close to the southern property boundary. The upward gradient observed in this cluster is corroborated by artesian conditions observed during historical gauging activities. Southwest of LL1mw-087/SCFmw-004, well cluster LL12mw-247/SCFmw-002 exhibits a downward gradient, potentially indicating an area of recharge for the Basal Sharon Conglomerate.

In the south-central portion of CJAG, near Load Lines 5 and 9, the groundwater elevation at SCFmw-001 and FWGmw-019 is approximately 80 to 90 feet lower than the groundwater elevation encountered in the Unconsolidated aquifer. Geologic mapping (Winslow and White 1966) indicates the Mercer Member (shale), Massillon Sandstone, and Sharon Member are present in this area. Shales within the Mercer Member and the Sharon Member-Shale unit likely act as aquitards, locally inhibiting flow between the Unconsolidated and Homewood aquifers to the Basal Sharon Conglomerate. A vertical gradient was not calculated for this area because suitable well pairs (i.e., located within 20 feet of each other) are not present.

To the east of SCFmw-001, where the Homewood, Massillon Sandstone, and Mercer Member have been eroded, the difference in groundwater elevations and the vertical gradient between the Basal Sharon Conglomerate and overlying aquifers decreases rapidly.

5.3.4 Upper Sharon and Basal Sharon Conglomerate Aquifers

Three well clusters screened in the Upper Sharon Sandstone and Basal Sharon Conglomerate were evaluated to estimate the vertical hydraulic gradient between these aquifers. The BKGmw018/BKGmw-024 cluster indicated an upward gradient of -0.038. At Load Line 12, well cluster FWGmw-018/ FWGmw-020 exhibited a downward gradient of 0.028. At Load Line 10, well cluster FWGmw-019/FWGmw-022 exhibited a downward gradient of 0.052. The gradients calculated between the Upper Sharon and Basal Sharon Conglomerate were relatively minor, indicating the two aquifers are hydraulically connected with minimal confining layers.

5.4 VARIANCES FROM RECENT POTENTIOMETRIC SURFACES

This section and its associated subsections compare and contrast the October 2022 potentiometric surface maps with the December 2021 potentiometric surface maps. The following subsections discuss variance between the 2022 and 2021 potentiometric surfaces for each of the four aquifers.

5.4.1 Unconsolidated Aquifer

A total of 191 wells were used to develop the potentiometric surface map in 2022. In general, the groundwater elevations observed in the Unconsolidated aquifer during the October 2022 gauging event were similar to those observed during the December 2021 event. On average, the October 2022 groundwater elevations were approximately 2.48 feet lower than in December 2021. The overall gradients show the primary gradient toward the east, with localized variances toward the north and south, as well as localized radial flow.

5.4.2 Homewood Sandstone Aquifer

Thirty-three wells were used to develop the potentiometric surface maps in 2022. In general, the groundwater elevations observed in the Homewood aquifer during the October 2022 gauging event were similar to those observed during the December 2021 event. The overall gradients indicated by the two events show the primary gradient toward the east/southeast, with a localized radial pattern near Load Line 9. On average, the October 2022 groundwater elevations were approximately 2.88 feet lower than in December 2021.

5.4.3 Upper Sharon Aquifer

Seventy-nine wells were used to develop the 2022 potentiometric map. In general, the groundwater elevations observed in the Upper Sharon aquifer during the October 2022 gauging event were similar to those observed during the December 2021 event, even with the additional wells. The overall gradients indicated by the two events show the primary gradient toward the east/southeast/northeast with a localized radial pattern near Load Line 2. On average, groundwater elevations in October 2022 were approximately 2.37 feet lower than in December 2021.

5.4.4 Basal Sharon Conglomerate Aquifer

Eleven wells were used to develop the 2022 potentiometric map. In general, the groundwater elevations observed in the Basal Sharon Conglomerate aquifer during the October 2022 gauging event were similar to those observed during the December 2021 event. In general, the overall gradients indicated by the two events show the primary gradient directed toward the east, with a northeasterly trend in the northeastern portion of CJAG. On average, October 2022 groundwater elevations were approximately 1.38 feet lower than in December 2021.

THIS PAGE INTENTIONALLY LEFT BLANK.

Table 5-1. Groundwater Elevations – Fall 2022

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-006	10/24/2022	36.96	958.43
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-007	10/24/2022	9.97	955.94
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-008	10/24/2022	9.76	956.32
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-009	10/24/2022	8.75	955.83
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-010	10/24/2022	28.68	953.46
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-011	10/24/2022	24.85	951.72
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-012	10/24/2022	24.6	953.05
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-013	10/24/2022	28.4	952.31
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-014	10/24/2022	22.64	950.85
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-015	10/24/2022	34.02	957.24
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-016	10/24/2022	37.29	959.31
RVAAP-01 Ramsdell Quarry Landfill	RQLmw-017	10/24/2022	30.45	960.78
RVAAP-02 Erie Burning Grounds	EBGmw-123	10/24/2022	11.28	936
RVAAP-02 Erie Burning Grounds	EBGmw-124	10/24/2022	4.94	935.91
RVAAP-02 Erie Burning Grounds	EBGmw-125	10/24/2022	13.73	935.62
RVAAP-02 Erie Burning Grounds	EBGmw-126	10/24/2022	3.72	936.35
RVAAP-02 Erie Burning Grounds	EBGmw-127	10/24/2022	6.57	935.96
RVAAP-02 Erie Burning Grounds	EBGmw-128	10/24/2022	9.3	935.29
RVAAP-02 Erie Burning Grounds	EBGmw-129	10/24/2022	8.04	935.78
RVAAP-02 Erie Burning Grounds	EBGmw-130	10/24/2022	8.66	934.8
RVAAP-02 Erie Burning Grounds	EBGmw-131	10/24/2022	12.61	936.93
RVAAP-04 Open Demolition Area #2	DA2mw-104	10/25/2022	22.78	1051.11
RVAAP-04 Open Demolition Area #2	DA2mw-105	10/24/2022	3.44	1041.9
RVAAP-04 Open Demolition Area #2	DA2mw-106	10/24/2022	N/A	N/A
RVAAP-04 Open Demolition Area #2	DA2mw-107	10/24/2022	9.13	1032.5
RVAAP-04 Open Demolition Area #2	DA2mw-108	10/25/2022	6.76	1025.6
RVAAP-04 Open Demolition Area #2	DA2mw-109	10/24/2022	16.97	1054.32
RVAAP-04 Open Demolition Area #2	DA2mw-110	10/24/2022	12.36	1051.42
RVAAP-04 Open Demolition Area #2	DA2mw-111	10/24/2022	8.3	1033.82
RVAAP-04 Open Demolition Area #2	DA2mw-112	10/24/2022	N/A	N/A
RVAAP-04 Open Demolition Area #2	DA2mw-113	10/24/2022	7.89	1029.22
RVAAP-04 Open Demolition Area #2	DA2mw-114	10/24/2022	5.42	1025.94
RVAAP-04 Open Demolition Area #2	DA2mw-115	10/24/2022	6.93	1030.61
RVAAP-04 Open Demolition Area #2	DETmw-001B	10/25/2022	25.31	1040.54
RVAAP-04 Open Demolition Area #2	DETmw-002	10/24/2022	32.32	1028.92
RVAAP-04 Open Demolition Area #2	DETmw-003	10/24/2022	9.17	1027.64
RVAAP-04 Open Demolition Area #2	DETmw-004	10/24/2022	9.97	1028.71
RVAAP-05 Winklepeck Burning Grounds	WBGmw-005	10/24/2022	3.51	1048.69
RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	10/24/2022	6.5	1005.66
RVAAP-05 Winklepeck Burning Grounds	WBGmw-007	10/24/2022	15.91	982.18
RVAAP-05 Winklepeck Burning Grounds	WBGmw-008	10/24/2022	12.98	992.73
RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	10/24/2022	12.48	1032.55
RVAAP-05 Winklepeck Burning Grounds	WBGmw-010	10/24/2022	5.99	1063.86
RVAAP-05 Winklepeck Burning Grounds	WBGmw-011	10/24/2022	8.65	1063.73
RVAAP-05 Winklepeck Burning Grounds	WBGmw-012	10/24/2022	25.21	1053.9
RVAAP-05 Winklepeck Burning Grounds	WBGmw-013	10/24/2022	12.9	1058.8
RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	10/24/2022	14.25	982.53
RVAAP-05 Winklepeck Burning Grounds	WBGmw-015	10/24/2022	11.35	1000.25
RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	10/24/2022	16.16	980.87
RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	10/24/2022	6.81	999.81

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	10/24/2022	20.26	970.65
RVAAP-05 Winklepeck Burning Grounds	WBGmw-019	10/24/2022	17.77	971.94
RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	10/24/2022	13.03	1030.74
RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	10/24/2022	9.93	1000.45
RVAAP-06 C Block Quarry	CBLmw-001	10/26/2022	44.56	1136.52
RVAAP-06 C Block Quarry	CBLmw-002	10/26/2022	38.98	1136.26
RVAAP-06 C Block Quarry	CBLmw-003	10/26/2022	37.68	1137.38
RVAAP-06 C Block Quarry	CBLmw-004	10/26/2022	37.42	1137.42
RVAAP-06 C Block Quarry	CBLmw-005	10/26/2022	24.51	1133.05
RVAAP-08 Load Line 1	LL1mw-063	10/24/2022	N/A	N/A
RVAAP-08 Load Line 1	LL1mw-064	10/24/2022	3.98	930.58
RVAAP-08 Load Line 1	LL1mw-065	10/24/2022	N/A	N/A
RVAAP-08 Load Line 1	LL1mw-067	10/24/2022	20.43	959.39
RVAAP-08 Load Line 1	LL1mw-078	10/24/2022	34.15	961.69
RVAAP-08 Load Line 1	LL1mw-079	10/24/2022	34.78	963.09
RVAAP-08 Load Line 1	LL1mw-080	10/24/2022	17.81	978.46
RVAAP-08 Load Line 1	LL1mw-081	10/24/2022	34.15	964.77
RVAAP-08 Load Line 1	LL1mw-082	10/24/2022	38.9	967.55
RVAAP-08 Load Line 1	LL1mw-083	10/24/2022	35.51	959.69
RVAAP-08 Load Line 1	LL1mw-084	10/24/2022	N/A	N/A
RVAAP-08 Load Line 1	LL1mw-085	10/24/2022	N/A	N/A
RVAAP-08 Load Line 1	LL1mw-086	10/24/2022	10.98	929.11
RVAAP-08 Load Line 1	LL1mw-087	10/24/2022	N/A	N/A
RVAAP-08 Load Line 1	LL1mw-088	10/24/2022	9.1	928.99
RVAAP-08 Load Line 1	LL1mw-089	10/24/2022	26.53	953.76
RVAAP-09 Load Line 2	LL2mw-059	10/25/2022	14.82	951.31
RVAAP-09 Load Line 2	LL2mw-060	10/25/2022	11.71	949.32
RVAAP-09 Load Line 2	LL2mw-261	10/25/2022	8.49	1002.91
RVAAP-09 Load Line 2	LL2mw-262	10/25/2022	12.31	1000.31
RVAAP-09 Load Line 2	LL2mw-263	10/25/2022	12.93	998.54
RVAAP-09 Load Line 2	LL2mw-264	10/25/2022	12.88	999
RVAAP-09 Load Line 2	LL2mw-265	10/25/2022	11.34	949.9
RVAAP-09 Load Line 2	LL2mw-266	10/25/2022	15.42	1000.86
RVAAP-09 Load Line 2	LL2mw-267	10/25/2022	13.24	1001.57
RVAAP-09 Load Line 2	LL2mw-268	10/25/2022	17.47	999.81
RVAAP-09 Load Line 2	LL2mw-269	10/25/2022	19.55	992.07
RVAAP-09 Load Line 2	LL2mw-270	10/25/2022	12.17	998.01
RVAAP-09 Load Line 2	LL2mw-271	10/25/2022	12.14	948.51
RVAAP-09 Load Line 2	LL2mw-272	10/25/2022	14.62	1003.18
RVAAP-10 Load Line 3	LL3mw-232	10/25/2022	23.68	976.73
RVAAP-10 Load Line 3	LL3mw-233	10/25/2022	28.08	976.28
RVAAP-10 Load Line 3	LL3mw-234	10/25/2022	14.42	992.14
RVAAP-10 Load Line 3	LL3mw-235	10/25/2022	N/A	N/A
RVAAP-10 Load Line 3	LL3mw-236	10/25/2022	21.32	990.38
RVAAP-10 Load Line 3	LL3mw-237	10/25/2022	N/A	N/A
RVAAP-10 Load Line 3	LL3mw-238	10/25/2022	N/A	N/A
RVAAP-10 Load Line 3	LL3mw-239	10/25/2022	31.11	972.39
RVAAP-10 Load Line 3	LL3mw-240	10/25/2022	28.97	978.55
RVAAP-10 Load Line 3	LL3mw-241	10/25/2022	N/A	N/A
RVAAP-10 Load Line 3	LL3mw-242	10/25/2022	19.82	979.5

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-10 Load Line 3	LL3mw-243	10/25/2022	20.82	970.34
RVAAP-10 Load Line 3	LL3mw-244	10/25/2022	18.03	970.21
RVAAP-10 Load Line 3	LL3mw-245	10/25/2022	15.98	964.72
RVAAP-10 Load Line 3	LL3mw-246	10/25/2022	24.51	963.79
RVAAP-11 Load Line 4	LL4mw-193	10/24/2022	8.61	974.31
RVAAP-11 Load Line 4	LL4mw-194	10/24/2022	11.87	971.89
RVAAP-11 Load Line 4	LL4mw-195	10/24/2022	12.76	969.83
RVAAP-11 Load Line 4	LL4mw-196	10/24/2022	14.75	969.8
RVAAP-11 Load Line 4	LL4mw-197	10/24/2022	15.62	969.84
RVAAP-11 Load Line 4	LL4mw-198	10/25/2022	12.01	971.41
RVAAP-11 Load Line 4	LL4mw-199	10/24/2022	8.9	968.38
RVAAP-11 Load Line 4	LL4mw-200	10/24/2022	19.23	968.7
RVAAP-11 Load Line 4	LL4mw-201	10/24/2022	10.81	966.67
RVAAP-12 Load Line 12	LL12mw-088	10/26/2022	9.72	971.34
RVAAP-12 Load Line 12	LL12mw-107	10/26/2022	13.75	966.4
RVAAP-12 Load Line 12	LL12mw-113	10/26/2022	13.8	966.38
RVAAP-12 Load Line 12	LL12mw-128	10/26/2022	12.7	965.54
RVAAP-12 Load Line 12	LL12mw-153	10/26/2022	11.1	966.75
RVAAP-12 Load Line 12	LL12mw-154	10/26/2022	14.18	964.88
RVAAP-12 Load Line 12	LL12mw-182	10/26/2022	14.13	970.29
RVAAP-12 Load Line 12	LL12mw-182ss	10/26/2022	14.58	969.9
RVAAP-12 Load Line 12	LL12mw-183	10/26/2022	16.42	966.56
RVAAP-12 Load Line 12	LL12mw-184	10/26/2022	15.55	967.61
RVAAP-12 Load Line 12	LL12mw-185	10/26/2022	10.93	970.38
RVAAP-12 Load Line 12	LL12mw-186	10/26/2022	13.59	964.72
RVAAP-12 Load Line 12	LL12mw-187	10/26/2022	16.32	963.62
RVAAP-12 Load Line 12	LL12mw-188	10/26/2022	12.82	967.81
RVAAP-12 Load Line 12	LL12mw-189	10/26/2022	N/A	N/A
RVAAP-12 Load Line 12	LL12mw-242	10/26/2022	16.58	964.62
RVAAP-12 Load Line 12	LL12mw-243	10/26/2022	14.15	966.64
RVAAP-12 Load Line 12	LL12mw-244	10/26/2022	16.4	964.25
RVAAP-12 Load Line 12	LL12mw-245	10/26/2022	13.25	966.79
RVAAP-12 Load Line 12	LL12mw-246	10/26/2022	20.13	964.7
RVAAP-12 Load Line 12	LL12mw-247	10/26/2022	10	973.71
RVAAP-13 Building 1200	B12mw-010	10/24/2022	20.88	985.04
RVAAP-13 Building 1200	B12mw-011	10/24/2022	22.67	984.03
RVAAP-13 Building 1200	B12mw-012	10/24/2022	21.75	984.57
RVAAP-13 Building 1200	B12mw-013	10/24/2022	20.38	983.56
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-166	10/26/2022	5.7	1103.16
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-167	10/26/2022	6.4	1109.5
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-168	10/26/2022	13.81	1120.1
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-169	10/26/2022	8.57	1112.01
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-170	10/26/2022	20.99	1121.27
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-171	10/26/2022	25.95	1117.6
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-172	10/26/2022	29.46	1120.63
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	10/26/2022	45.23	1120.71
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-174	10/26/2022	15.5	1124.47
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	10/26/2022	20.16	1120.57
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-176	10/26/2022	11.72	1120.19
RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-177	10/26/2022	16.35	1112.22

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-19 Landfill North of Winklepeck Burning Grounds	LNWmw-024	10/26/2022	14.36	1023.64
RVAAP-19 Landfill North of Winklepeck Burning Grounds	LNWmw-025	10/26/2022	5.57	1023.56
RVAAP-19 Landfill North of Winklepeck Burning Grounds	LNWmw-026	10/26/2022	13.89	1013.91
RVAAP-19 Landfill North of Winklepeck Burning Grounds	LNWmw-027	10/26/2022	8.99	1018.14
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-001	10/26/2022	18.55	1063.65
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-002	10/26/2022	19.22	1064
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-003	10/26/2022	19.57	1064.88
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-004	10/26/2022	17.88	1063.92
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-005	10/26/2022	18.8	1063.62
RVAAP-28 Suspected Mustard Agent Burial Site	MBSmw-006	10/26/2022	18.27	1063.56
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-001	10/25/2022	8.48	966.78
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-002	10/25/2022	6.4	965.91
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-003	10/24/2022	4.04	968.88
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-004	10/24/2022	13.18	968.02
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-005	10/24/2022	13.47	960.11
RVAAP-29 Upper and Lower Cobbs Ponds	CPmw-006	10/24/2022	9.53	955.6
RVAAP-33 Load Line 6	LL6mw-001	10/25/2022	15.11	1109.05
RVAAP-33 Load Line 6	LL6mw-002	10/25/2022	N/A	N/A
RVAAP-33 Load Line 6	LL6mw-003	10/25/2022	19.79	1105.59
RVAAP-33 Load Line 6	LL6mw-004	10/25/2022	19.5	1105.89
RVAAP-33 Load Line 6	LL6mw-005	10/25/2022	14.23	1106.24
RVAAP-33 Load Line 6	LL6mw-006	10/25/2022	N/A	N/A
RVAAP-33 Load Line 6	LL6mw-007	10/25/2022	10.2	1105.42
RVAAP-33 Load Line 6	LL6mw-008	10/25/2022	N/A	N/A
RVAAP-33 Load Line 6	LL6mw-009	10/25/2022	17.55	1105.66
RVAAP-34 Sand Creek Disposal Road Landfill	SCLmw-001	10/25/2022	N/A	N/A
RVAAP-34 Sand Creek Disposal Road Landfill	SCLmw-002	10/25/2022	N/A	N/A
RVAAP-34 Sand Creek Disposal Road Landfill	SCLmw-003	10/25/2022	N/A	N/A
RVAAP-38 NACA Test Area	NTAmw-107	10/25/2022	13.7	1066.6
RVAAP-38 NACA Test Area	NTAmw-108	10/25/2022	18.78	1066.84
RVAAP-38 NACA Test Area	NTAmw-109	10/25/2022	13.22	1066.62
RVAAP-38 NACA Test Area	NTAmw-110	10/25/2022	15.51	1067.11
RVAAP-38 NACA Test Area	NTAmw-111	10/25/2022	7.45	1073.49
RVAAP-38 NACA Test Area	NTAmw-112	10/25/2022	10.16	1068.17
RVAAP-38 NACA Test Area	NTAmw-113	10/25/2022	8.42	1067.26
RVAAP-38 NACA Test Area	NTAmw-114	10/25/2022	7.88	1070.83
RVAAP-38 NACA Test Area	NTAmw-115	10/25/2022	15.6	1074.05
RVAAP-38 NACA Test Area	NTAmw-116	10/25/2022	8.2	1086.13
RVAAP-38 NACA Test Area	NTAmw-117	10/25/2022	16.63	1077.91
RVAAP-38 NACA Test Area	NTAmw-118	10/25/2022	10.69	1070.75
RVAAP-38 NACA Test Area	NTAmw-119	10/25/2022	13.65	1065.88
RVAAP-38 NACA Test Area	NTAmw-120	10/25/2022	34.47	1040.73
RVAAP-39 Load Line 5	LL5mw-001	10/25/2022	22.55	1105.37
RVAAP-39 Load Line 5	LL5mw-002	10/25/2022	23.35	1105.33
RVAAP-39 Load Line 5	LL5mw-003	10/25/2022	22.12	1105.58
RVAAP-39 Load Line 5	LL5mw-004	10/25/2022	20.52	1105.29

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-39 Load Line 5	LL5mw-005	10/25/2022	24.06	1105.36
RVAAP-39 Load Line 5	LL5mw-006	10/25/2022	22.71	1105.29
RVAAP-40 Load Line 7	LL7mw-001	10/25/2022	22.79	1106.85
RVAAP-40 Load Line 7	LL7mw-002	10/25/2022	19.26	1110.29
RVAAP-40 Load Line 7	LL7mw-003	10/25/2022	13.81	1107.03
RVAAP-40 Load Line 7	LL7mw-004	10/25/2022	17.13	1109.19
RVAAP-40 Load Line 7	LL7mw-005	10/25/2022	23.97	1111.9
RVAAP-40 Load Line 7	LL7mw-006	10/25/2022	13.88	1109.68
RVAAP-41 Load Line 8	LL8mw-001	10/25/2022	14.93	1106.53
RVAAP-41 Load Line 8	LL8mw-002	10/25/2022	21.92	1102.59
RVAAP-41 Load Line 8	LL8mw-003	10/25/2022	16.38	1102.67
RVAAP-41 Load Line 8	LL8mw-004	10/25/2022	14.9	1100.85
RVAAP-41 Load Line 8	LL8mw-005	10/25/2022	16.4	1099.33
RVAAP-41 Load Line 8	LL8mw-006	10/25/2022	21.66	1095.49
RVAAP-42 Load Line 9	LL9mw-001	10/25/2022	17.5	1117.12
RVAAP-42 Load Line 9	LL9mw-002	10/25/2022	16.62	1110.68
RVAAP-42 Load Line 9	LL9mw-003	10/25/2022	15.79	1119.97
RVAAP-42 Load Line 9	LL9mw-004	10/25/2022	22.94	1108.89
RVAAP-42 Load Line 9	LL9mw-005	10/25/2022	18.85	1112.08
RVAAP-42 Load Line 9	LL9mw-006	10/25/2022	21.42	1108.46
RVAAP-42 Load Line 9	LL9mw-007	10/25/2022	11.64	1108.35
RVAAP-43 Load Line 10	LL10mw-001	10/25/2022	26.4	1106.37
RVAAP-43 Load Line 10	LL10mw-002	10/25/2022	19.47	1107.66
RVAAP-43 Load Line 10	LL10mw-003	10/25/2022	22.82	1107.46
RVAAP-43 Load Line 10	LL10mw-004	10/25/2022	15.58	1106.81
RVAAP-43 Load Line 10	LL10mw-005	10/25/2022	17.94	1107.73
RVAAP-43 Load Line 10	LL10mw-006	10/25/2022	14.78	1109.05
RVAAP-44 Load Line 11	LL11mw-001	10/26/2022	12.44	1087.72
RVAAP-44 Load Line 11	LL11mw-002	10/26/2022	4.01	1075.99
RVAAP-44 Load Line 11	LL11mw-003	10/26/2022	3.56	1084.93
RVAAP-44 Load Line 11	LL11mw-004	10/26/2022	2.92	1081.81
RVAAP-44 Load Line 11	LL11mw-005	10/26/2022	11.87	1067.54
RVAAP-44 Load Line 11	LL11mw-006	10/26/2022	7.68	1078.82
RVAAP-44 Load Line 11	LL11mw-007	10/26/2022	16.03	1065.97
RVAAP-44 Load Line 11	LL11mw-008	10/26/2022	5.61	1082.13
RVAAP-44 Load Line 11	LL11mw-009	10/26/2022	4.87	1086.67
RVAAP-44 Load Line 11	LL11mw-010	10/26/2022	6.87	1075.81
RVAAP-44 Load Line 11	LL11mw-011	10/26/2022	9.25	1070.41
RVAAP-44 Load Line 11	LL11mw-012	10/26/2022	20.35	1059.47
RVAAP-49 Central Burn Pits	CBPmw-001	10/25/2022	16.87	958.97
RVAAP-49 Central Burn Pits	CBPmw-002	10/25/2022	13.18	956.86
RVAAP-49 Central Burn Pits	CBPmw-003	10/25/2022	14.42	960.25
RVAAP-49 Central Burn Pits	CBPmw-004	10/25/2022	13.02	958.11
RVAAP-49 Central Burn Pits	CBPmw-005	10/25/2022	14.03	957.56
RVAAP-49 Central Burn Pits	CBPmw-006	10/25/2022	9.91	957.73
RVAAP-49 Central Burn Pits	CBPmw-007	10/25/2022	18.45	957.92
RVAAP-49 Central Burn Pits	CBPmw-008	10/25/2022	18.09	955.1
RVAAP-49 Central Burn Pits	CBPmw-009	10/25/2022	12.82	959.12
RVAAP-50 Atlas Scrap Yard	ASYmw-001	10/24/2022	14.43	966.7
RVAAP-50 Atlas Scrap Yard	ASYmw-002	10/24/2022	16.71	968.53

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-50 Atlas Scrap Yard	ASYmw-003	10/24/2022	15.31	966.9
RVAAP-50 Atlas Scrap Yard	ASYmw-004	10/24/2022	13.39	966.27
RVAAP-50 Atlas Scrap Yard	ASYmw-005	10/24/2022	13.64	966.16
RVAAP-50 Atlas Scrap Yard	ASYmw-006	10/24/2022	15.98	967.03
RVAAP-50 Atlas Scrap Yard	ASYmw-007	10/24/2022	16.41	967.75
RVAAP-50 Atlas Scrap Yard	ASYmw-008	10/24/2022	13.09	965.76
RVAAP-50 Atlas Scrap Yard	ASYmw-009	10/24/2022	14.69	968.01
RVAAP-50 Atlas Scrap Yard	ASYmw-010	10/24/2022	14.32	966.73
RVAAP-66 Facility-wide Groundwater	FWGmw-001	10/25/2022	10.29	945.79
RVAAP-66 Facility-wide Groundwater	FWGmw-002	10/24/2022	24.23	948.33
RVAAP-66 Facility-wide Groundwater	FWGmw-003	10/26/2022	5.39	1126.03
RVAAP-66 Facility-wide Groundwater	FWGmw-004	N/A	N/A	N/A
RVAAP-66 Facility-wide Groundwater	FWGmw-005	10/26/2022	22.8	1146.76
RVAAP-66 Facility-wide Groundwater	FWGmw-006	10/26/2022	12.24	1171.55
RVAAP-66 Facility-wide Groundwater	FWGmw-007	10/26/2022	25.65	1049.22
RVAAP-66 Facility-wide Groundwater	FWGmw-008	10/26/2022	7.01	1104.06
RVAAP-66 Facility-wide Groundwater	FWGmw-009	10/26/2022	2.75	1098.85
RVAAP-66 Facility-wide Groundwater	FWGmw-010	10/24/2022	14.02	947.59
RVAAP-66 Facility-wide Groundwater	FWGmw-011	10/24/2022	5.24	935.83
RVAAP-66 Facility-wide Groundwater	FWGmw-012	10/24/2022	3.79	937.06
RVAAP-66 Facility-wide Groundwater	FWGmw-013	10/24/2022	23.83	1035.14
RVAAP-66 Facility-wide Groundwater	FWGmw-014	10/26/2022	5.43	1131.6
RVAAP-66 Facility-wide Groundwater	FWGmw-015	10/26/2022	10.19	1003.78
RVAAP-66 Facility-wide Groundwater	FWGmw-016	10/26/2022	18.94	994.91
RVAAP-66 Facility-wide Groundwater	FWGmw-018	10/25/2022	23.06	960.97
RVAAP-66 Facility-wide Groundwater	FWGmw-019	10/25/2022	116.79	1015.44
RVAAP-66 Facility-wide Groundwater	FWGmw-020	10/25/2022	23.98	960.6
RVAAP-66 Facility-wide Groundwater	FWGmw-021	10/25/2022	23.78	964.19
RVAAP-66 Facility-wide Groundwater	FWGmw-022	10/25/2022	115.9	1016.41
RVAAP-66 Facility-wide Groundwater	FWGmw-023	10/25/2022	118.12	1034.25
RVAAP-66 Facility-wide Groundwater	FWGmw-024	10/25/2022	14.91	948.25
RVAAP-66 Facility-wide Groundwater	SCFmw-001	10/25/2022	90.5	1029.67
RVAAP-66 Facility-wide Groundwater	SCFmw-002	10/26/2022	20.93	963.09
RVAAP-66 Facility-wide Groundwater	SCFmw-003	10/25/2022	9.41	948.51
RVAAP-66 Facility-wide Groundwater	SCFmw-004	10/24/2022	1.6	942.02
RVAAP-66 Facility-wide Groundwater	SCFmw-005	10/24/2022	13.18	947.08
RVAAP-66 Facility-wide Groundwater	SCFmw-006	10/25/2022	18.9	946.48
RVAAP-66 Facility-wide Groundwater	BKGmw-004	10/25/2022	14.93	950.23
RVAAP-66 Facility-wide Groundwater	BKGmw-005	10/26/2022	14.85	1134.59
RVAAP-66 Facility-wide Groundwater	BKGmw-006	10/24/2022	24.87	1001.51
RVAAP-66 Facility-wide Groundwater	BKGmw-008	10/25/2022	19.94	950.46
RVAAP-66 Facility-wide Groundwater	BKGmw-010	10/24/2022	20.34	985.95
RVAAP-66 Facility-wide Groundwater	BKGmw-012	10/24/2022	12.38	985.19
RVAAP-66 Facility-wide Groundwater	BKGmw-013	10/26/2022	14.94	971.65
RVAAP-66 Facility-wide Groundwater	BKGmw-015	10/24/2022	N/A	N/A
RVAAP-66 Facility-wide Groundwater	BKGmw-016	10/26/2022	8.22	1090.2
RVAAP-66 Facility-wide Groundwater	BKGmw-017	10/26/2022	21.56	1111.24
RVAAP-66 Facility-wide Groundwater	BKGmw-018	10/24/2022	16.56	1026.5
RVAAP-66 Facility-wide Groundwater	BKGmw-019	10/26/2022	22.16	1086.08
RVAAP-66 Facility-wide Groundwater	BKGmw-020	10/24/2022	11.36	1053.64

Table 5-1. Groundwater Elevations – Fall 2022 (Continued)

RVAAP Area	Well ID	Date Gauged	Water Level Depth (feet)	Groundwater Elevation
RVAAP-66 Facility-wide Groundwater	BKGmw-021	10/24/2022	N/A	N/A
RVAAP-66 Facility-wide Groundwater	BKGmw-022	10/26/2022	15.87	1151.45
RVAAP-66 Facility-wide Groundwater	BKGmw-023	10/26/2022	7.92	1175.7
RVAAP-66 Facility-wide Groundwater	BKGmw-024	10/24/2022	11.18	1032.6
RVAAP-66 Facility-wide Groundwater	BKGmw-025	10/26/2022	42.15	1068.45
RVAAP-69 Building 1048 Fire Station	069mw-001	10/26/2022	13.76	1013.49
RVAAP-69 Building 1048 Fire Station	069mw-002	10/26/2022	12.41	1015.87
RVAAP-69 Building 1048 Fire Station	069mw-003	10/26/2022	13.16	1014.12
RVAAP-69 Building 1048 Fire Station	069mw-004	10/26/2022	10.84	1013.35
RVAAP-69 Building 1048 Fire Station	069mw-005	10/26/2022	10.74	1012.44
RVAAP-69 Building 1048 Fire Station	069mw-006	10/26/2022	13.62	1014.77
RVAAP-69 Building 1048 Fire Station	069mw-007	10/26/2022	14.87	1014.48
RVAAP-69 Building 1048 Fire Station	069mw-008	10/26/2022	9.91	1013.96
RVAAP-69 Building 1048 Fire Station	069mw-009	10/26/2022	9.86	1013.68
RVAAP-69 Building 1048 Fire Station	069mw-010	10/26/2022	10.98	1013.11
RVAAP-69 Building 1048 Fire Station	069mw-011	10/26/2022	10.72	1012.47
RVAAP-69 Building 1048 Fire Station	069mw-012	10/26/2022	10.58	1012.28
RVAAP-69 Building 1048 Fire Station	069mw-013	10/26/2022	14.61	1017.95
RVAAP-69 Building 1048 Fire Station	069mw-014	10/26/2022	11.95	1015.82
RVAAP-74 Building 1034 Motor Pool Hydraulic Lift	074mw-001	10/26/2022	13.23	1008.78
RVAAP-74 Building 1034 Motor Pool Hydraulic Lift	074mw-002	10/26/2022	13.42	1008.22
RVAAP-74 Building 1034 Motor Pool Hydraulic Lift	074mw-003	10/26/2022	13.85	1006.96

ID = Identifier
N/A = Not Applicable
NACA = National Advisory Committee for Aeronautics
RVAAP = Ravenna Army Ammunition Plant

Table 5-2. Hydraulic Gradient and Groundwater Flow Velocity

Formation	Hydraulic Gradient	General Gradient	Porosity	Hydraulic Conductivity		Seepage Velocity	
			%	cm/sec	ft/day	ft/day	ft/yr
Unconsolidated	0.008	East	27.40%	4.27E-04	1.21	0.035	13
Unconsolidated	0.011	Southwest	27.40%	4.27E-04	1.21	0.049	18
Unconsolidated	0.019	East	27.40%	4.27E-04	1.21	0.084	31
Homewood Sandstone	0.004	Southeast	13.90%	2.81E-03	7.97	0.229	84
Homewood Sandstone	0.004	Southeast	13.90%	2.81E-03	7.97	0.229	84
Homewood Sandstone	0.004	East-Northeast	13.90%	2.81E-03	7.97	0.229	84
Homewood Sandstone	0.015	East	13.90%	2.81E-03	7.97	0.860	314
Upper Sharon	0.017	East-Northeast	10.50%	4.46E-03	12.64	2.046	747
Upper Sharon	0.014	East-Northeast	10.50%	4.46E-03	12.64	1.685	615
Upper Sharon	0.023	Southeast	10.50%	4.46E-03	12.64	2.769	1011
Basal Sharon Conglomerate	0.004	East	10.50%	1.00E-04	0.28	0.011	4
Basal Sharon Conglomerate	0.006	East	10.50%	1.00E-04	0.28	0.016	6

cm/sec = Centimeters per Second
ft/day = Feet per Day
ft/yr = Feet per Year

Table 5-3. Vertical Gradient Calculations

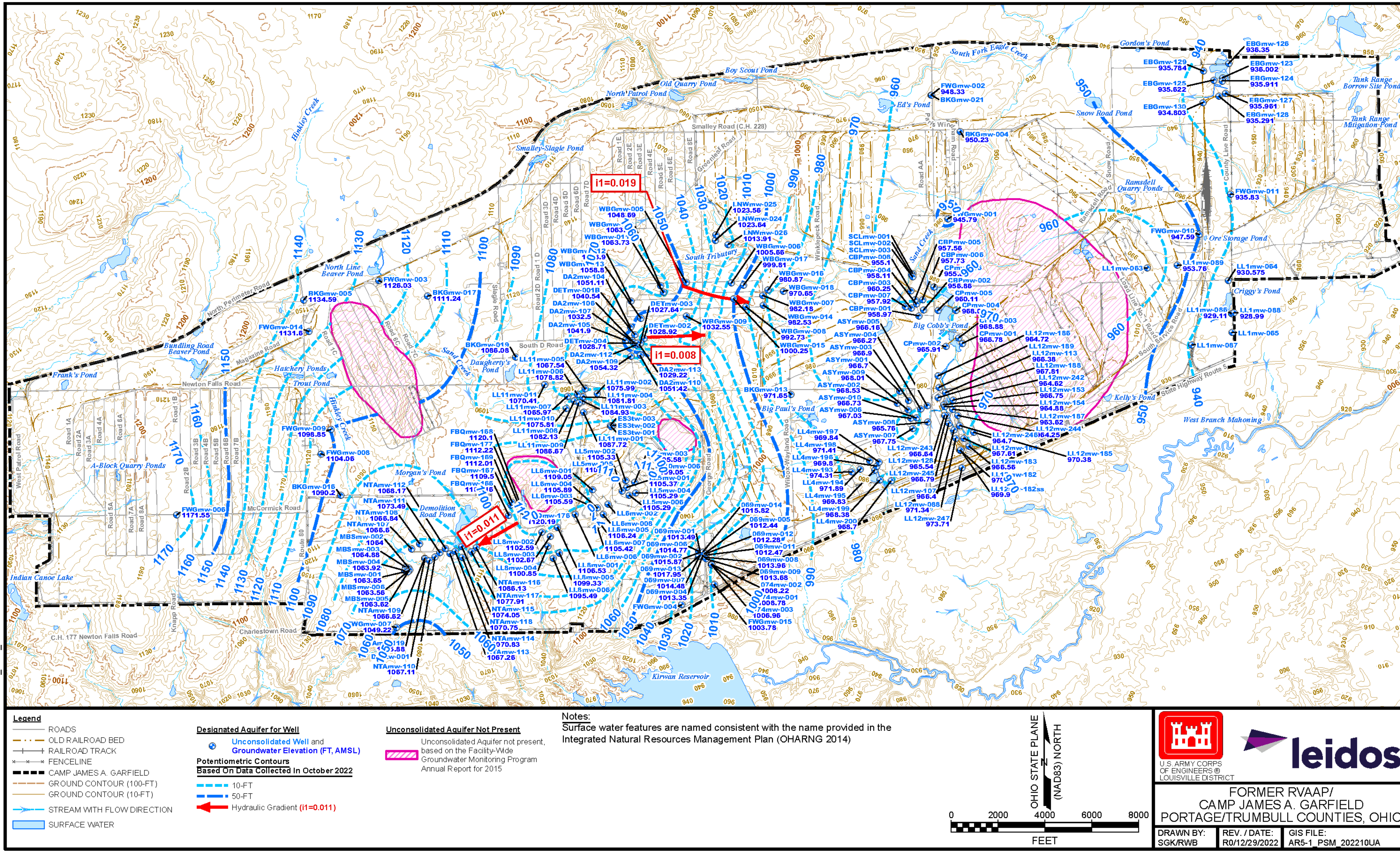
RVAAP Area	Well ID	Monitored Zone/Aquifer	TOC Elevation (ft amsl)	Groundwater Elevation (ft amsl)	Screen Midpoint Elevation (ft amsl)	Vertical Hydraulic Gradient (ft/ft)	Vertical Gradient Direction	Comments
Unconsolidated and Homewood Aquifers								
Load Line 6	LL6mw-008	Unconsolidated	1123.61	N/A	1108.60	N/A	N/A	Could not be obtained due to water level being below the top of the pump
Load Line 6	LL6mw-009	Homewood Sandstone	1123.21	1105.66	1086.90			
Unconsolidated and Upper Sharon Aquifers								
Erie Burning Grounds	EBGmw-125	Unconsolidated	949.35	935.62	928.01	-0.028	Up	Upward gradient from Upper Sharon toward Unconsolidated Aquifer
Erie Burning Grounds	EBGmw-131	Upper Sharon	949.54	936.93	881.50			
Facility Wide Groundwater	FWGmw-015	Unconsolidated	1013.97	1003.78	993.10	0.214	Down	Downward gradient from Unconsolidated toward Upper Sharon Aquifer
Facility Wide Groundwater	FWGmw-016	Upper Sharon	1013.85	994.91	951.60			
Load Line 4	LL4mw-199	Unconsolidated	977.28	968.38	959.90	0.037	Down	Downward gradient from Unconsolidated toward Upper Sharon Aquifer
Load Line 4	LL4mw-201	Upper Sharon	977.48	966.67	913.90			
NACA Testing Area	NTAmw-113	Unconsolidated	1075.68	1067.26	1050.61	0.287	Down	Downward gradient from Unconsolidated toward Upper Sharon Aquifer
NACA Testing Area	NTAmw-120	Upper Sharon	1075.20	1040.73	958.17			
Winklepeck Burning Grounds	WBGmw-009	Unconsolidated	1045.03	1032.55	1026.32	0.085	Down	Downward gradient from Unconsolidated toward Upper Sharon Aquifer
Winklepeck Burning Grounds	WBGmw-020	Upper Sharon	1043.77	1030.74	1005.00			
Winklepeck Burning Grounds	WBGmw-018	Unconsolidated	990.91	970.65	971.50	-0.047	Up	Upward gradient from Unconsolidated toward Upper Sharon Aquifer
Winklepeck Burning Grounds	WBGmw-019	Upper Sharon	989.71	971.94	944.20			
Winklepeck Burning Grounds	WBGmw-006	Unconsolidated	1012.16	1005.66	997.33	0.210	Down	Downward gradient from Unconsolidated toward Upper Sharon Aquifer
Winklepeck Burning Grounds	WBGmw-021	Upper Sharon	1010.38	1000.45	972.50			

Table 5-3. Vertical Gradient Calculations (Continued)

RVAAP Area	Well ID	Monitored Zone/Aquifer	TOC Elevation (ft amsl)	Groundwater Elevation (ft amsl)	Screen Midpoint Elevation (ft amsl)	Vertical Hydraulic Gradient (ft/ft)	Vertical Gradient Direction	Comments
Unconsolidated and Basal Sharon Conglomerate Aquifers								
Load Line 1	LL1mw-087	Unconsolidated	943.78	N/A	929.3	N/A	N/A	Could not be obtained due to water level being below the top of the pump
Basal Sharon Conglomerate	SCFmw-004	Basal Sharon Conglomerate	943.62	942.02	836.32			
Load Line 12	LL12mw-247	Unconsolidated	983.71	973.71	965.8	0.084	Down	Downward gradient from Unconsolidated toward Basal Sharon Conglomerate Aquifer
Basal Sharon Conglomerate	SCFmw-002	Basal Sharon Conglomerate	984.02	963.09	839.74			
Upper Sharon and Basal Sharon Conglomerate Aquifers								
Background	BKGmw-018	Upper Sharon	1043.06	1026.5	1021.32	-0.046	Up	Upward gradient from Basal Sharon toward Upper Sharon Aquifer
Background	BKGmw-024	Basal Sharon Conglomerate	1043.78	1032.6	889.89			
Load Line 10	FWGmw-022	Upper Sharon	1132.31	1016.41	970.81	0.046	Down	Minor downward gradient from Basal Sharon toward Upper Sharon Aquifer
Load Line 10	FWGmw-019	Basal Sharon Conglomerate	1132.23	1015.44	900.08			
Load Line 12	FWGmw-020	Upper Sharon	984.58	960.6	942.03	-0.004	Minor Up	Minor upward gradient from Basal Sharon toward Upper Sharon Aquifer
Load Line 12	FWGmw-018	Basal Sharon Conglomerate	984.03	960.97	839.92			

A groundwater elevation could not be obtained for LL6mw-008 due to the water level being below the top of the pump, which is used along with LL6mw-009 to calculate a vertical gradient.

amsl = Above Mean Sea Level
ID = Identifier
ft = Feet
ft/ft = Feet per Foot
N/A = Not Applicable
NACA = National Advisory Committee for Aeronautics
RVAAP = Ravenna Army Ammunition Plant
TOC = Total Organic Carbon



\\chs-fs01\cad\19009\MXD\AR\2022\AR5-1_PSM_202210UA.mxd

Figure 5-1. Potentiometric Surface Map, October 2022 – Unconsolidated Aquifer

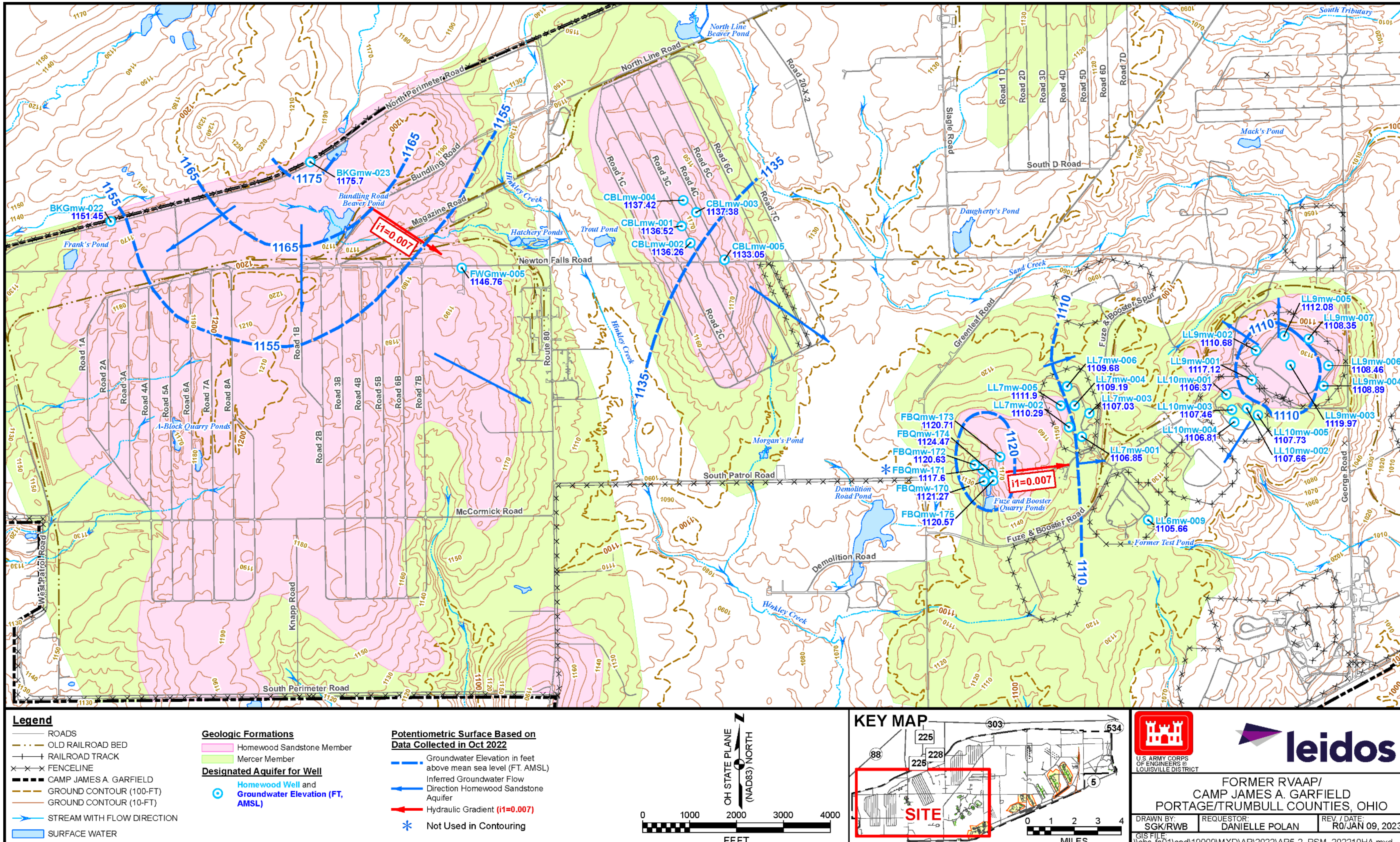


Figure 5-2. Potentiometric Surface Map, October 2022 – Homewood Sandstone Aquifer

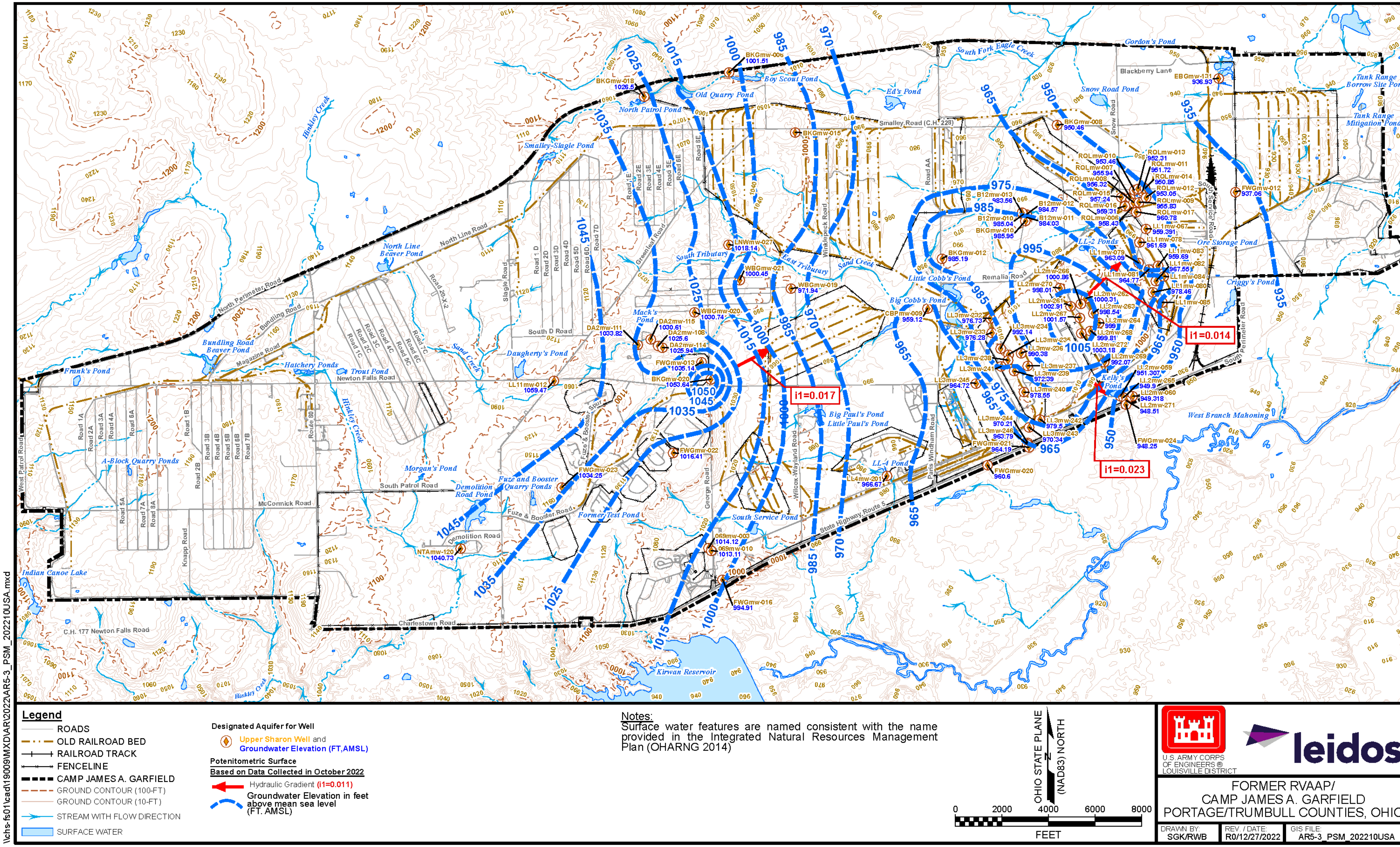


Figure 5-3. Potentiometric Surface Map, October 2022 – Upper Sharon Sandstone Aquifer

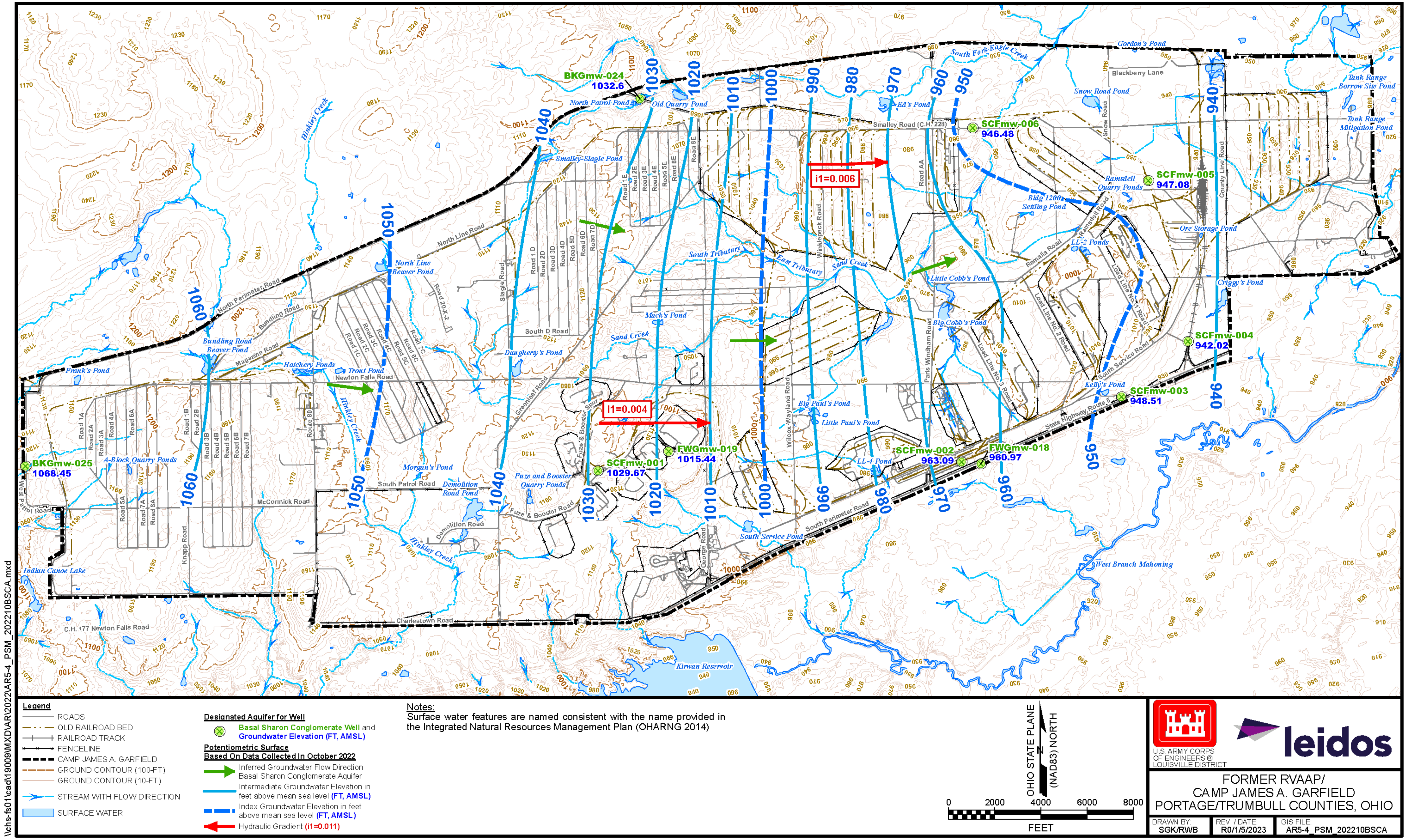


Figure 5-4. Potentiometric Surface Map, October 2022 – Basal Sharon Conglomerate Aquifer

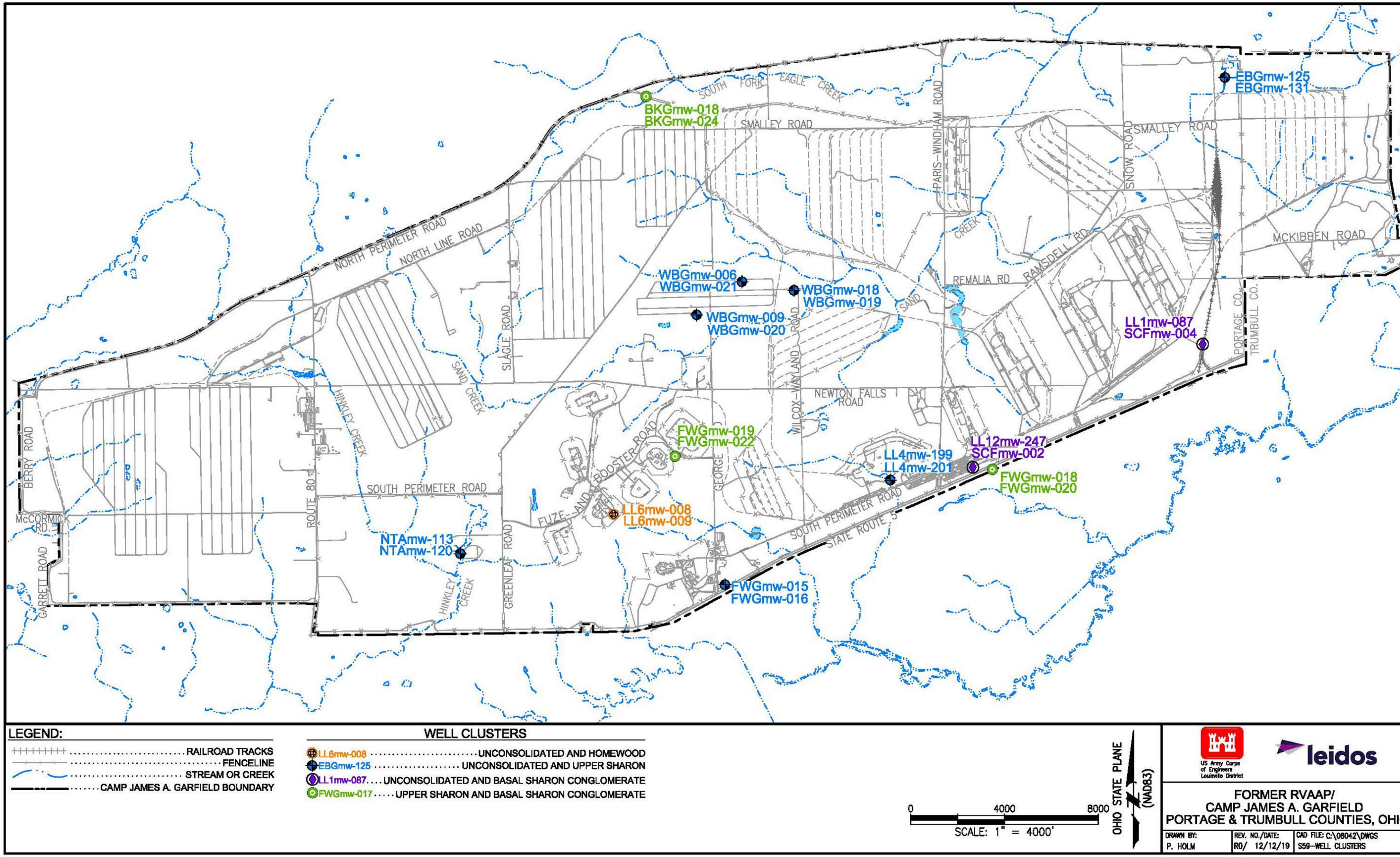


Figure 5-5. Monitoring Well Clusters within Camp James A. Garfield

THIS PAGE INTENTIONALLY LEFT BLANK.

6.0 2022 RESULTS AND DISCUSSION

This section provides a discussion of the 2022 results for each analyzed chemical group for the four aquifers at CJAG. In addition, this section explains the screening level used to assess the reported chemical concentrations and provides figures depicting exceedances of the screening levels.

6.1 SCREENING LEVELS

Screening levels have been established for a basis of comparison against actual results. The chemical specific screening level is the highest concentration among the maximum contaminant level (MCL), Resident Adult/Child facility-wide cleanup goal (FWCUG), or U.S. Environmental Protection Agency (USEPA) Residential tap water regional screening level (RSL). For metals, if the aquifer-specific background concentration is greater than the previously mentioned criteria, that background concentration is used as the screening level. The concentrations are compared to the applicable screening criteria for each chemical.

For this evaluation, updated background concentrations per the *Background Study for Metals for RVAAP-66 Facility-wide Groundwater* (Leidos 2019) are used. The FWCUGs are listed in Tables 5-8 through 5-10 in the *Facility-wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (SAIC 2010). If a chemical does not have one of these values, a cleanup goal may need to be developed in coordination with Ohio EPA.

Chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the human food supply and often are added to food as supplements. These essential nutrients are provided in the tables presenting exceedances of screening level; however, to streamline the narrative section, the essential nutrients are not discussed in the text provided in the following subsections.

The applicable screening level used in this report for each chemical are presented in Table 6-1. The cleanup goal or regulatory limit chosen for screening purposes also is presented in this table. Table 6-2 presents the exceedances during the Spring 2022 sampling event, and Table 6-3 presents the exceedances during the Fall 2022 sampling event. Table 6-4 presents the pH levels in 2022 that were outside a typical pH range of 5 to 9 S.U.

6.2 UNCONSOLIDATED

Twenty-three wells screened in the Unconsolidated aquifer were sampled in 2022. The following subsections summarize chemicals exceeding the screening level by chemical group.

6.2.1 Metals

Two wells (DETmw-003 and DETmw-004) screened in the Unconsolidated aquifer were sampled for total metals in Spring and Fall 2022. Only arsenic and manganese exceeded their screening level in groundwater at DETmw-003, and only manganese exceeded its screening level in groundwater at DETmw-004. These chemicals are discussed below and presented in Figure 6-1.

Arsenic – Arsenic exceeded the MCL of 0.01 mg/L in the primary and duplicate samples collected during the Fall 2022 event. Arsenic exceeded the MCL at DETmw-003 during the Fall 2022 event at concentrations of 0.011 and 0.012 mg/L for the primary and duplicate samples, respectively. Arsenic did not exceed the screening level in the Spring 2022 sample.

Manganese – Manganese exceeded the background screening level of 0.075 mg/L in the primary and duplicate samples collected during the Spring and Fall 2022 events. Monitoring well DETmw-003 exceeded the screening criteria in Spring 2022 at a concentration of 0.23 mg/L for both the primary and duplicate samples. Manganese exceeded screening criteria at DETmw-003 during the Fall 2022 event at a concentration of 0.25 mg/L for both the primary and duplicate samples. Manganese only exceeded screening criteria at DETmw-004 during the Fall 2022 event at a concentration of 0.2 mg/L.

6.2.2 Explosives and Propellants

Eighteen wells screened in the Unconsolidated aquifer were sampled for explosives in Spring and Fall 2022. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) exceeded its screening level in three wells (LL1mw-086, WBGmw-006, and WBGmw-009), and 2,4,6-Trinitrotoluene (TNT) exceeded its screening level in one well (LL1mw-086). Results are presented in Figure 6-2.

RDX – Samples collected from the following wells exceeded the RSL of 0.97 µg/L for RDX in Spring and Fall 2022: WBGmw-006 (6.9 and 7.2 µg/L), and WBGmw-009 (1.3 and 3.5 µg/L). Groundwater in LL1mw-086 only exceeded the RSL for RDX in Spring 2022 at a concentration of 1.1 µg/L.

TNT – TNT exceeded the RSL of 0.98 µg/L in one sample collected during the Spring 2022 sampling event. TNT exceeded the RSL at LL1mw-086 during the Spring 2022 event at a concentration of 1.3 µg/L. The RSL for TNT was not exceeded during the Fall 2022 event.

6.2.3 Semivolatile Organic Compounds

Two wells (DETmw-003 and DETmw-004) screened in the Unconsolidated aquifer were sampled for SVOCs in 2022. SVOC concentrations were below their respective screening level.

6.2.4 Volatile Organic Compounds

Two wells (DETmw-003 and DETmw-004) screened in the Unconsolidated aquifer were sampled for VOCs in 2022. VOC concentrations were below their respective screening level.

6.2.5 Pesticides and Polychlorinated Biphenyls

Two wells (DETmw-003 and DETmw-004) screened in the Unconsolidated aquifer were sampled for pesticides and polychlorinated biphenyls (PCBs) in 2022. Pesticides and PCBs were not detected in any of the samples.

6.2.6 Cyanide

Two wells (DETmw-003 and DETmw-004) screened in the Unconsolidated aquifer were sampled for cyanide in 2022. Cyanide was not detected in any of the samples.

6.2.7 Nitrate

Eight wells screened in the Unconsolidated aquifer were sampled for nitrate in 2022. The results compared to the MCL of 10 mg/L are summarized below:

- Nitrate in LL12mw-244, LL12mw-245, LL12mw-246, WBGmw-006, WBGmw-009, and WBGmw-018 did not exceed the MCL.
- Nitrate in LL12mw-185 exceeded the MCL in both the primary and duplicate samples with estimated concentrations of 71J and 74 mg/L in Spring 2022, and 61J and 62J mg/L in Fall 2022.
- Nitrate in LL12mw-187 exceeded the MCL in Fall 2022 at a concentration of 1,600 mg/L, but concentrations did not exceed the MCL during the Spring 2022 event.

These results are presented in Figure 6-3.

6.2.8 pH

The typical pH range for naturally occurring groundwater is approximately 5 to 9 S.U. Three Unconsolidated aquifer wells sampled in 2022 (FWGmw-010, LL1mw-063, and LL1mw-089) had pH levels out of the normal range in one or both sampling events in 2022. The pH for these wells in 2022 is summarized below:

- FWGmw-010 had a pH of 4.50 S.U. in Spring 2022 and 5.08 S.U. in Fall 2022.
- LL1mw-063 had a pH of 4.67 S.U. in Spring 2022. The pH could not be measured for this well in Fall 2022, as the well was purged dry several times to collect a grab sample.
- LL1mw-089 had a pH of 4.67 S.U. in Spring 2022 and 5.10 S.U. in Fall 2022.

6.3 HOMEWOOD SANDSTONE

Four wells screened in the Homewood Sandstone aquifer were sampled in 2022. The following subsections summarize chemicals exceeding the screening level by chemical group.

6.3.1 Metals

No wells screened in the Homewood Sandstone aquifer were sampled for total or dissolved metals in 2022.

6.3.2 Explosives and Propellants

Three wells (FBQmw-173, FBQmw-174, and FBQmw-175) screened in the Homewood Sandstone aquifer were sampled for explosives and propellants in 2022. Concentrations were not detected above screening levels at FBQmw-175 in Spring or Fall 2022.

The following explosive/propellant concentrations exceeding screening levels at FBQmw-173:

- 2-Nitrotoluene estimated concentrations exceeded the Resident Adult FWCUG of 0.37 µg/L in Fall 2022 (0.49 J µg/L); concentrations did not exceed the Resident Adult FWCUG during the Spring 2022 event.

The following explosive/propellant concentrations exceeded screening levels at FBQmw-174 in Spring 2022; the well was dry during the Fall 2022 event and no sample could be collected:

- TNT concentrations exceeded the RSL of 0.98 µg/L in Spring 2022 (5.6 µg/L).
- 2,4-Dinitrotoluene (DNT) concentrations exceeded the RSL of 0.24 µg/L in Spring 2022 (0.37 µg/L).
- 2-Amino-4,6-DNT concentrations exceeded the RSL of 3.9 µg/L in Spring 2022 (8.7 µg/L).
- 4-Amino-2,6-DNT concentrations exceeded the RSL of 3.9 µg/L in Spring 2022 (17 µg/L).

These results are presented in Figure 6-4.

6.3.3 Volatile Organic Compounds

One well (LL10mw-003) screened in the Homewood Sandstone aquifer was sampled for the VOC carbon tetrachloride. Carbon tetrachloride did not exceed the screening level in 2022.

6.3.4 pH

The typical pH range for naturally occurring groundwater is approximately 5 to 9 S.U. One Homewood Sandstone aquifer well sampled in 2022 (FBQmw-174) had pH levels out of the normal range in one or both sampling events in 2022. The pH for these wells in 2022 is summarized below:

- FBQmw-174 had a pH of 4.88 S.U. in Spring 2022. FBQmw-174 was dry in Fall 2022; therefore, no sample was collected.

6.4 UPPER SHARON

Nineteen wells screened in the Upper Sharon were sampled in 2022. Although they were screened within the Upper Sharon, FWGmw-020, FWGmw-021, and FWGmw-024 will be addressed separately as offsite wells in Section 6.6 and are not discussed with the other Upper Sharon wells. The following subsections summarize chemicals exceeding the screening level by chemical group.

6.4.1 Explosives and Propellants

Sixteen wells screened in the Upper Sharon aquifer were sampled for explosives in 2022. The explosives that exceeded their respective screening level were TNT, 2,4 DNT, 2,6-DNT, 2-amino-4,6-DNT, 4-amino-2,6-DNT, and RDX. These results are discussed below and presented in Figure 6-5.

TNT – Samples collected from LL1mw-083 (1.9 and 2.4 µg/L) exceeded the RSL of 0.98 µg/L in Spring or Fall 2022. Monitoring well LL3mw-237 exceeded the RSL in Spring 2022 at an estimated concentration of 42J µg/L and was not detected in Fall 2022. Monitoring well LL3mw-238 exceeded the RSL in Fall 2022 at an estimated concentration of 28J µg/L and was not detected in Spring 2022. Monitoring well LL1mw-084 exceeded the RSL in both the primary and duplicate samples at concentrations of 2.7 and 2.9 µg/L in Spring 2022 and estimated concentrations of 2.5J and 2.9J µg/L in Fall 2022.

2,4-DNT – Samples collected from LL1mw-083 (2.5 and 2.9 µg/L) exceeded the RSL of 0.24 µg/L in Spring and Fall 2022. The sample from LL1mw-084 only exceeded the RSL in Fall 2022 in both the primary and duplicate samples at concentrations of 1.6 and 2 µg/L. The sample from LL2mw-059 only exceeded the RSL in Fall 2022 at a concentration of 0.35 µg/L.

2,6-DNT – Samples collected from LL1mw-083 exceeded the RSL of 0.049 µg/L at a concentration of 1.0 µg/L in Spring 2022 and 1.7 µg/L in Fall 2022.

2-Amino-4,6-DNT – Samples collected from LL1mw-083 exceeded the RSL of 3.9 µg/L in Spring and Fall 2022 at concentrations of 8.5 and 9.6 µg/L respectively. Monitoring well LL1mw-084 exceeded the RSL in both the primary and duplicate samples at concentrations of 7.7 and 7.8 µg/L in Spring 2022 and 6.1 and 7.3 µg/L in Fall 2022. Monitoring well LL3mw-237 only exceeded the RSL in Spring 2022 at a concentration of 6.9 µg/L.

4-Amino-2,6-DNT – Samples collected from LL1mw-083 exceeded the RSL of 3.9 µg/L in Spring and Fall 2022 at concentrations of 16 and 14 µg/L respectively. Monitoring well LL1mw-084 exceeded the RSL in both the primary and duplicate samples at concentrations of 23 and 24 µg/L in Spring 2022 and 15 and 18 µg/L in Fall 2022. Monitoring well LL3mw-238 only exceeded the RSL in Fall 2022 at a concentration of 28 µg/L. Monitoring well LL3mw-237 only exceeded the RSL in Spring 2022 at an estimated concentration of 27J µg/L.

RDX – Samples collected from the following wells exceeded the RSL of 0.97 µg/L in Spring or Fall 2022. RDX only exceeded the RSL in LL1mw-080 in Spring 2022 at a concentration of 26 µg/L. RDX only exceeded the RSL in LL1mw-081 in Spring 2022 at an estimated concentration of 1.0J µg/L. RDX only exceeded the RSL in LL3mw-238 in Fall 2022 at a concentration of 3.4 µg/L. RDX only exceeded the RSL in LL3mw-237 in Spring 2022 at a concentration of 6.7 µg/L.

6.4.2 Volatile Organic Compounds

No wells screened in the Upper Sharon aquifer were sampled and analyzed for VOCs in 2022.

6.4.3 Nitrate

Six wells (LL1mw-080, LL1mw-083, LL1mw-084, LL2mw-059, LL3mw-238, and LL3mw-239) screened in the Upper Sharon aquifer were sampled for nitrate in Spring and Fall 2022. Nitrate was detected in groundwater from each well, but all concentrations were below the MCL of 10 µg/L.

6.4.4 Nitrite

Six wells (LL1mw-080, LL1mw-083, LL1mw-084, LL2mw-059, LL3mw-238, and LL3mw-239) screened in the Upper Sharon aquifer were sampled for nitrite in Spring and Fall 2022. Nitrite was not detected in any sample.

6.4.5 Sulfate

Six wells (LL1mw-080, LL1mw-083, LL1mw-084, LL2mw-059, LL3mw-238, and LL3mw-239) screened in the Upper Sharon aquifer were sampled for sulfate in Spring and Fall 2022. Sulfate was detected in all wells during the Spring and Fall sampling events. Sulfate does not have a screening level.

6.4.6 Sulfide

Six wells (LL1mw-080, LL1mw-083, LL1mw-084, LL2mw-059, LL3mw-238, and LL3mw-239) screened in the Upper Sharon aquifer were sampled for sulfide in Spring and Fall 2022. Sulfide was not detected in any sample.

6.4.7 pH

The typical pH range for naturally occurring groundwater is approximately 5 to 9 S.U. Groundwater at LL1mw-083 had a pH of 4.17 S.U. in Spring 2022 and a pH 4.41 S.U. in Fall 2022.

6.5 BASAL SHARON CONGLOMERATE

Two wells (FWGmw-018 and SCFmw-004) screened in the Basal Sharon Conglomerate were sampled in Spring and Fall 2022. Although FWGmw-018 is screened within the Basal Sharon Conglomerate, it will be summarized separately as an offsite well in Section 6.6.

The following subsections summarize chemicals exceeding the screening level by chemical group.

6.5.1 Explosives and Propellants

Explosives or propellants were not detected in Spring or Fall 2022.

6.5.2 pH

All pH levels were within the standard pH range of 5 to 9 S.U.

6.6 OFFSITE WELLS

Four offsite wells, located along State Route 5 and bordering the southern edge of the property, were sampled in Spring and Fall 2022. Three wells were screened in the Upper Sharon (FWGmw-020, FWGmw-021, and FWGmw-024), and one well was screened in the Basal Sharon Conglomerate (FWGmw-018). The following subsections summarize chemicals exceeding the screening level by chemical group.

6.6.1 Explosives and Propellants

Two offsite wells (FWGmw-021 and FWGmw-024) were sampled for explosives and propellants. The only explosives and propellants detected were 2-amino-4,6-DNT, 4-amino-2,6-DNT, and RDX from FWGmw-021 at concentrations below screening levels.

6.6.2 Nitrate

Two offsite wells (FWGmw-018 and FWGmw-020) were sampled for nitrate. Nitrate was not detected in Spring of Fall 2022.

6.6.3 pH

All offsite wells had pH levels within the standard range of 5 to 9 S.U.

Table 6-1. Groundwater Screening Levels

Zone	Analysis Type	Chemical	Units	CAS No	NGT CUG	Resident CUG	MCL	Tap Water RSL	Background	GW Screening Level	GW Screening Level Source
Same for all zones	Anions	Nitrate	mg/L	14797-55-8	52.283	1.666	10	3.2	N/A	10	MCL
Same for all zones	Anions	Nitrite	mg/L	14797-65-0			1	0.2	N/A	1	MCL
Same for all zones	Anions	Sulfate	mg/L	14808-79-8					N/A		
Same for all zones	Anions	Sulfide	mg/L	18496-25-8					N/A		
Same for all zones	Explosives/Propellants	1,3,5-Trinitrobenzene	µg/L	99-35-4				59	N/A	59	RSL
Same for all zones	Explosives/Propellants	1,3-DNB	µg/L	99-65-0	3.28	0.104		0.2	N/A	0.2	RSL
Same for all zones	Explosives/Propellants	TNT	µg/L	118-96-7	16.4	0.521		0.98	N/A	0.98	RSL
Same for all zones	Explosives/Propellants	2,4-Diamino-6-nitrotoluene	µg/L	6629-29-4					N/A		
Same for all zones	Explosives/Propellants	2,4-DNT	µg/L	121-14-2	1.29	0.12		0.24	N/A	0.24	RSL
Same for all zones	Explosives/Propellants	2,6-Diamino-4-nitrotoluene	µg/L	59229-75-3					N/A		
Same for all zones	Explosives/Propellants	2,6-DNT	µg/L	606-20-2	1.31	0.122		0.049	N/A	0.122	RA
Same for all zones	Explosives/Propellants	2-Amino-4,6-DNT	µg/L	35572-78-2	6.55	0.209		3.9	N/A	3.9	RSL
Same for all zones	Explosives/Propellants	2-Nitrotoluene	µg/L	88-72-2	3.99	0.37		0.31	N/A	0.37	RA
Same for all zones	Explosives/Propellants	3,5-Dinitroaniline	µg/L	618-87-1					N/A		
Same for all zones	Explosives/Propellants	3-Nitrotoluene	µg/L	99-08-1				0.17	N/A	0.17	RSL
Same for all zones	Explosives/Propellants	4-Amino-2,6-DNT	µg/L	19406-51-0	6.55	0.209		3.9	N/A	3.9	RSL
Same for all zones	Explosives/Propellants	4-Nitrotoluene	µg/L	99-99-0	54	5.01		4.3	N/A	5.01	RA
Same for all zones	Explosives/Propellants	DNX	µg/L	80251-29-2					N/A		
Same for all zones	Explosives/Propellants	HMX	µg/L	2691-41-0				100	N/A	100	RSL
Same for all zones	Explosives/Propellants	MNX	µg/L	5755-27-1					N/A		
Same for all zones	Explosives/Propellants	Nitrobenzene	µg/L	98-95-3	16.4	0.521		0.14	N/A	0.521	RC
Same for all zones	Explosives/Propellants	Nitroglycerin	µg/L	55-63-0	54	5.01		0.2	N/A	5.01	RA
Same for all zones	Explosives/Propellants	PETN	µg/L	78-11-5				3.9	N/A	3.9	RSL
Same for all zones	Explosives/Propellants	RDX	µg/L	121-82-4	8.34	0.774		0.97	N/A	0.97	RSL
Same for all zones	Explosives/Propellants	TNX	µg/L	13980-04-6					N/A		
Same for all zones	Explosives/Propellants	Tetryl	µg/L	479-45-8				3.9	N/A	3.9	RSL
Same for all zones	Miscellaneous	Alkalinity	mg/L	N33					N/A		
Same for all zones	Miscellaneous	Ammonia	mg/L	7664-41-7					N/A		
Same for all zones	Miscellaneous	Cyanide	mg/L	57-12-5			0.2	0.00015	N/A	0.2	MCL
Same for all zones	Miscellaneous	TOC	mg/L	N997					N/A		
Same for all zones	PCBs	PCB-1016	µg/L	12674-11-2				0.14	N/A	0.14	RSL
Same for all zones	PCBs	PCB-1221	µg/L	11104-28-2				0.0047	N/A	0.0047	RSL
Same for all zones	PCBs	PCB-1232	µg/L	11141-16-5				0.0047	N/A	0.0047	RSL
Same for all zones	PCBs	PCB-1242	µg/L	53469-21-9	2.29	0.213		0.0078	N/A	0.213	RA
Same for all zones	PCBs	PCB-1248	µg/L	12672-29-6				0.0078	N/A	0.0078	RSL
Same for all zones	PCBs	PCB-1254	µg/L	11097-69-1	0.655	0.021		0.0078	N/A	0.021	RC
Same for all zones	PCBs	PCB-1260	µg/L	11096-82-5	2.29	0.213		0.0078	N/A	0.213	RA
Same for all zones	Pesticides	4,4'-DDD	µg/L	72-54-8	0.639	0.059		0.0063	N/A	0.059	RA
Same for all zones	Pesticides	4,4'-DDE	µg/L	72-55-9	0.503	0.047		0.046	N/A	0.047	RA
Same for all zones	Pesticides	4,4'-DDT	µg/L	50-29-3	0.294	0.027		0.23	N/A	0.23	RSL
Same for all zones	Pesticides	Aldrin	µg/L	309-00-2	0.051	0.005		0.00092	N/A	0.005	RA
Same for all zones	Pesticides	Dieldrin	µg/L	60-57-1	0.038	0.004		0.0018	N/A	0.004	RA
Same for all zones	Pesticides	Endosulfan I	µg/L	959-98-8				10	N/A	10	RSL
Same for all zones	Pesticides	Endosulfan II	µg/L	33213-65-9				10	N/A	10	RSL
Same for all zones	Pesticides	Endosulfan sulfate	µg/L	1031-07-8				10	N/A	10	RSL
Same for all zones	Pesticides	Endrin	µg/L	72-20-8			2	0.23	N/A	2	MCL
Same for all zones	Pesticides	Endrin aldehyde	µg/L	7421-93-4				0.23	N/A	0.23	RSL
Same for all zones	Pesticides	Endrin ketone	µg/L	53494-70-5				0.23	N/A	0.23	RSL
Same for all zones	Pesticides	Heptachlor	µg/L	76-44-8	0.153	0.014	0.4	0.0014	N/A	0.4	MCL

Table 6-1. Groundwater Screening Levels (Continued)

Zone	Analysis Type	Chemical	Units	CAS No	NGT CUG	Resident CUG	MCL	Tap Water RSL	Background	GW Screening Level	GW Screening Level Source
Same for all zones	Pesticides	Heptachlor epoxide	µg/L	1024-57-3	0.101	0.009	0.2	0.0014	N/A	0.2	MCL
Same for all zones	Pesticides	Lindane	µg/L	58-89-9	0.55	0.051	0.2	0.042	N/A	0.2	MCL
Same for all zones	Pesticides	Methoxychlor	µg/L	72-43-5			40	3.7	N/A	40	MCL
Same for all zones	Pesticides	Toxaphene	µg/L	8001-35-2	0.518	0.048	3	0.071	N/A	3	MCL
Same for all zones	Pesticides	alpha-BHC	µg/L	319-84-6	0.146	0.014		0.0072	N/A	0.014	RA
Same for all zones	Pesticides	alpha-Chlordane	µg/L	5103-71-9				0.02	N/A	0.02	RSL
Same for all zones	Pesticides	beta-BHC	µg/L	319-85-7	0.51	0.047		0.025	N/A	0.047	RA
Same for all zones	Pesticides	delta-BHC	µg/L	319-86-8					N/A		
Same for all zones	Pesticides	gamma-Chlordane	µg/L	5103-74-2				0.02	N/A	0.02	RSL
Same for all zones	SVOCs	1-Methylnaphthalene	µg/L	90-12-0				1.1	N/A	1.1	RSL
Same for all zones	SVOCs	2,4,5-Trichlorophenol	µg/L	95-95-4				120	N/A	120	RSL
Same for all zones	SVOCs	2,4,6-Trichlorophenol	µg/L	88-06-2				1.2	N/A	1.2	RSL
Same for all zones	SVOCs	2,4-Dichlorophenol	µg/L	120-83-2				4.6	N/A	4.6	RSL
Same for all zones	SVOCs	2,4-Dimethylphenol	µg/L	105-67-9				36	N/A	36	RSL
Same for all zones	SVOCs	2,4-Dinitrophenol	µg/L	51-28-5				3.9	N/A	3.9	RSL
Same for all zones	SVOCs	2,4-DNT	µg/L	121-14-2	1.29	0.12		0.24	N/A	0.24	RSL
Same for all zones	SVOCs	2,6-DNT	µg/L	606-20-2	1.31	0.122		0.049	N/A	0.122	RA
Same for all zones	SVOCs	2-Chlorophenol	µg/L	95-57-8				9.1	N/A	9.1	RSL
Same for all zones	SVOCs	2-Methyl-4,6-dinitrophenol	µg/L	534-52-1				0.15	N/A	0.15	RSL
Same for all zones	SVOCs	2-Methylnaphthalene	µg/L	91-57-6				3.6	N/A	3.6	RSL
Same for all zones	SVOCs	2-Methylphenol	µg/L	95-48-7				93	N/A	93	RSL
Same for all zones	SVOCs	2-Nitrophenol	µg/L	88-75-5					N/A		
Same for all zones	SVOCs	4-Chloro-3-methylphenol	µg/L	59-50-7				140	N/A	140	RSL
Same for all zones	SVOCs	4-Nitrophenol	µg/L	100-02-7					N/A		
Same for all zones	SVOCs	Acenaphthene	µg/L	83-32-9				53	N/A	53	RSL
Same for all zones	SVOCs	Acenaphthylene	µg/L	208-96-8				12	N/A	12	RSL
Same for all zones	SVOCs	Anthracene	µg/L	120-12-7				180	N/A	180	RSL
Same for all zones	SVOCs	Benz(a)anthracene	µg/L	56-55-3	0.042	0.004		0.03	N/A	0.03	RSL
Same for all zones	SVOCs	Benzo(a)pyrene	µg/L	50-32-8	0.002	0.00023	0.2	0.025	N/A	0.2	MCL
Same for all zones	SVOCs	Benzo(b)fluoranthene	µg/L	205-99-2	0.024	0.002		0.25	N/A	0.25	RSL
Same for all zones	SVOCs	Benzo(ghi)perylene	µg/L	191-24-2				12	N/A	12	RSL
Same for all zones	SVOCs	Benzo(k)fluoranthene	µg/L	207-08-9				2.5	N/A	2.5	RSL
Same for all zones	SVOCs	Bis(2-ethylhexyl)phthalate	µg/L	117-81-7	9.7	0.9	6	5.6	N/A	6	MCL
Same for all zones	SVOCs	Butyl benzyl phthalate	µg/L	85-68-7				16	N/A	16	RSL
Same for all zones	SVOCs	Chrysene	µg/L	218-01-9				25	N/A	25	RSL
Same for all zones	SVOCs	Di-n-butyl phthalate	µg/L	84-74-2				90	N/A	90	RSL
Same for all zones	SVOCs	Di-n-octylphthalate	µg/L	117-84-0				20	N/A	20	RSL
Same for all zones	SVOCs	Dibenz(a,h)anthracene	µg/L	53-70-3	0.002	0.00015		0.025	N/A	0.025	RSL
Same for all zones	SVOCs	Diethyl phthalate	µg/L	84-66-2				1500	N/A	1500	RSL
Same for all zones	SVOCs	Dimethyl phthalate	µg/L	131-11-3					N/A		
Same for all zones	SVOCs	Fluoranthene	µg/L	206-44-0				80	N/A	80	RSL
Same for all zones	SVOCs	Fluorene	µg/L	86-73-7				29	N/A	29	RSL
Same for all zones	SVOCs	Indeno(1,2,3-cd)pyrene	µg/L	193-39-5	0.024	0.002		0.25	N/A	0.25	RSL
Same for all zones	SVOCs	Naphthalene	µg/L	91-20-3				0.17	N/A	0.17	RSL
Same for all zones	SVOCs	Nitrobenzene	µg/L	98-95-3	16.4	0.521		0.14	N/A	0.521	RC
Same for all zones	SVOCs	Pentachlorophenol	µg/L	87-86-5	0.797	0.074	1	0.041	N/A	1	MCL
Same for all zones	SVOCs	Phenanthrene	µg/L	85-01-8				12	N/A	12	RSL
Same for all zones	SVOCs	Phenol	µg/L	108-95-2				580	N/A	580	RSL
Same for all zones	SVOCs	Pyrene	µg/L	129-00-0				12	N/A	12	RSL
Same for all zones	SVOCs	Total Cresols	µg/L	1319-77-3				150	N/A	150	RSL
Same for all zones	VOCs	1,1,1-Trichloroethane	µg/L	71-55-6			200	800	N/A	200	MCL
Same for all zones	VOCs	1,1,2,2-Tetrachloroethane	µg/L	79-34-5	0.744	0.069		0.076	N/A	0.076	RSL

Table 6-1. Groundwater Screening Levels (Continued)

Zone	Analysis Type	Chemical	Units	CAS No	NGT CUG	Resident CUG	MCL	Tap Water RSL	Background	GW Screening Level	GW Screening Level Source
Same for all zones	VOCs	1,1,2-Trichloroethane	µg/L	79-00-5			5	0.041	N/A	5	MCL
Same for all zones	VOCs	1,1-Dichloroethane	µg/L	75-34-3				2.8	N/A	2.8	RSL
Same for all zones	VOCs	1,1-Dichloroethene	µg/L	75-35-4			7	28	N/A	7	MCL
Same for all zones	VOCs	1,2-Dibromoethane	µg/L	106-93-4			0.05	0.0075	N/A	0.05	MCL
Same for all zones	VOCs	1,2-Dichloroethane	µg/L	107-06-2	1.67	0.155	5	0.17	N/A	5	MCL
Same for all zones	VOCs	1,2-Dichloroethene	µg/L	540-59-0			70	3.6	N/A	70	MCL
Same for all zones	VOCs	1,2-Dichloropropane	µg/L	78-87-5			5	0.82	N/A	5	MCL
Same for all zones	VOCs	2-Butanone	µg/L	78-93-3				560	N/A	560	RSL
Same for all zones	VOCs	2-Hexanone	µg/L	591-78-6				3.8	N/A	3.8	RSL
Same for all zones	VOCs	4-Methyl-2-pentanone	µg/L	108-10-1				630	N/A	630	RSL
Same for all zones	VOCs	Acetone	µg/L	67-64-1				1400	N/A	1400	RSL
Same for all zones	VOCs	Benzene	µg/L	71-43-2	4.64	0.431	5	0.46	N/A	5	MCL
Same for all zones	VOCs	Bromobenzene	µg/L	108-86-1				6.2	N/A	6.2	RSL
Same for all zones	VOCs	Bromochloromethane	µg/L	74-97-5				8.3	N/A	8.3	RSL
Same for all zones	VOCs	Bromodichloromethane	µg/L	75-27-4				0.13	N/A	0.13	RSL
Same for all zones	VOCs	Bromoform	µg/L	75-25-2				3.3	N/A	3.3	RSL
Same for all zones	VOCs	Bromomethane	µg/L	74-83-9				0.75	N/A	0.75	RSL
Same for all zones	VOCs	Carbon disulfide	µg/L	75-15-0				81	N/A	81	RSL
Same for all zones	VOCs	Carbon tetrachloride	µg/L	56-23-5	2.2	0.204	5	0.46	N/A	5	MCL
Same for all zones	VOCs	Chlorobenzene	µg/L	108-90-7			100	7.8	N/A	100	MCL
Same for all zones	VOCs	Chloroethane	µg/L	75-00-3				2100	N/A	2100	RSL
Same for all zones	VOCs	Chloroform	µg/L	67-66-3	2.23	0.207	80	0.22	N/A	80	MCL
Same for all zones	VOCs	Chloromethane	µg/L	74-87-3				19	N/A	19	RSL
Same for all zones	VOCs	Dibromochloromethane	µg/L	124-48-1				0.87	N/A	0.87	RSL
Same for all zones	VOCs	Ethylbenzene	µg/L	100-41-4			700	1.5	N/A	700	MCL
Same for all zones	VOCs	Methylene chloride	µg/L	75-09-2	57.5	5.34	5	11	N/A	5	MCL
Same for all zones	VOCs	Styrene	µg/L	100-42-5			100	120	N/A	100	MCL
Same for all zones	VOCs	Tetrachloroethene	µg/L	127-18-4	1.05	0.098	5	4.1	N/A	5	MCL
Same for all zones	VOCs	Toluene	µg/L	108-88-3			1000	110	N/A	1000	MCL
Same for all zones	VOCs	Trichloroethene	µg/L	79-01-6	0.336	0.031	5	0.28	N/A	5	MCL
Same for all zones	VOCs	Vinyl chloride	µg/L	75-01-4			2	0.019	N/A	2	MCL
Same for all zones	VOCs	Xylenes, total	µg/L	1330-20-7			10000	19	N/A	10000	MCL
Same for all zones	VOCs	cis-1,3-Dichloropropene	µg/L	10061-01-5				0.47	N/A	0.47	RSL
Same for all zones	VOCs	trans-1,3-Dichloropropene	µg/L	10061-02-6				0.47	N/A	0.47	RSL
Unconsolidated	Metals, Total/Filtered	Aluminum	mg/L	7429-90-5	31.981	1.028		2	0.386	2	RSL
Unconsolidated	Metals, Total/Filtered	Antimony	mg/L	7440-36-0	0.0117	0.00039	0.006	0.00078	0	0.006	MCL
Unconsolidated	Metals, Total/Filtered	Arsenic	mg/L	7440-38-2	0.000608	5.6E-05	0.01	0.000052	0.003	0.01	MCL
Unconsolidated	Metals, Total/Filtered	Barium	mg/L	7440-39-3	6.332	0.204	2	0.38	0.034	2	MCL
Unconsolidated	Metals, Total/Filtered	Beryllium	mg/L	7440-41-7			0.004	0.0025	0	0.004	MCL
Unconsolidated	Metals, Total/Filtered	Cadmium	mg/L	7440-43-9	0.0132	0.00046	0.005	0.00092	0	0.005	MCL
Unconsolidated	Metals, Total/Filtered	Calcium	mg/L	7440-70-2					107		
Unconsolidated	Metals, Total/Filtered	Chromium	mg/L	7440-47-3	33.087	1.214	0.1	2.2	0.002	0.1	MCL
Unconsolidated	Metals, Total/Filtered	Cobalt	mg/L	7440-48-4	0.654	0.0208		0.0006	0.00083	0.0208	RC
Unconsolidated	Metals, Total/Filtered	Copper	mg/L	7440-50-8			1.3	0.08	0.005	1.3	MCL
Unconsolidated	Metals, Total/Filtered	Iron	mg/L	7439-89-6	9.671	0.31		1.4	1.91	1.91	BKG
Unconsolidated	Metals, Total/Filtered	Lead	mg/L	7439-92-1			0.015	0.015	0.00099	0.015	MCL
Unconsolidated	Metals, Total/Filtered	Magnesium	mg/L	7439-95-4					55.3		
Unconsolidated	Metals, Total/Filtered	Manganese	mg/L	7439-96-5	1.421	0.0463		0.043	0.075	0.075	BKG
Unconsolidated	Metals, Total/Filtered	Mercury	mg/L	7439-97-6			0.002	0.000063	0	0.002	MCL
Unconsolidated	Metals, Total/Filtered	Nickel	mg/L	7440-02-0	0.654	0.0208		0.039	0.002	0.039	RSL
Unconsolidated	Metals, Total/Filtered	Potassium	mg/L	7440-09-7					4.84		
Unconsolidated	Metals, Total/Filtered	Selenium	mg/L	7782-49-2			0.05	0.01	0.00099	0.05	MCL

Table 6-1. Groundwater Screening Levels (Continued)

Zone	Analysis Type	Chemical	Units	CAS No	NGT CUG	Resident CUG	MCL	Tap Water RSL	Background	GW Screening Level	GW Screening Level Source
Unconsolidated	Metals, Total/Filtered	Silver	mg/L	7440-22-4				0.0094	0	0.0094	RSL
Unconsolidated	Metals, Total/Filtered	Sodium	mg/L	7440-23-5					18.2		
Unconsolidated	Metals, Total/Filtered	Thallium	mg/L	7440-28-0	0.00261	8.3E-05	0.002	0.00002	0	0.002	MCL
Unconsolidated	Metals, Total/Filtered	Vanadium	mg/L	7440-62-2	0.185	0.00638		0.0086	0.0005	0.0086	RSL
Unconsolidated	Metals, Total/Filtered	Zinc	mg/L	7440-66-6	9.756	0.312		0.6	0.005	0.6	RSL

µg/L = Micrograms per Liter
BHC = Hexachlorocyclohexane
BKG = Background
CAS = Chemical Abstracts Service
CUG = Cleanup Goal
DDD = Dichlorodiphenyldichloroethane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichlorodiphenyltrichloroethane
DNB = Dinitrobenzene
DNT = Dinitrotoluene
DNX = Hexahydro-1,3-Dinitroso-5-Dinitro-1,3,5-Triazine
GW = Groundwater
HMX = Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
MNX = Hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-Triazine
N/A = Not Applicable
NGT = National Guard Trainee
PCB = Polychlorinated Biphenyl
PETN = Pentaerythritol Tetranitrate
RA = Resident Adult Facility-wide Cleanup Goal
RC = Resident Child Facility-wide Cleanup Goal
RDX = Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RSL = Regional Screening Level
SVOC = Semivolatile Organic Compound
TNT = Trinitrotoluene
TNX = Hexahydro-1,3,5-Trinitroso-1,3,5-Triazine
TOC = Total Organic Carbon
VOC = Volatile Organic Compound

Table 6-2. Screening Level Exceedances – Spring 2022 Sample Event

Zone	Well	Date Collected	Sample ID	Sample Type	Analysis Type	Chemical	Result	Units	Validation Qual	Background Criteria	GW Screening Level	GW Screening Criteria Source
Homewood	FBQmw-174	6/28/2022	FBQmw-174-220601-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	5.6	ug/L			0.98	RSL
Homewood	FBQmw-174	6/28/2022	FBQmw-174-220601-GW	Grab	Explosives/Propellants	2,4-Dinitrotoluene	0.37	ug/L			0.24	RSL
Homewood	FBQmw-174	6/28/2022	FBQmw-174-220601-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	8.7	ug/L			3.9	RSL
Homewood	FBQmw-174	6/28/2022	FBQmw-174-220601-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	17	ug/L			3.9	RSL
Unconsolidated	DETmw-003	6/23/2022	DET-003-220602-GW	Field Duplicate	Metals, Total	Manganese	0.23	mg/L		0.075	0.075	BKG
Unconsolidated	DETmw-003	6/23/2022	DET-003-220601-GW	Grab	Metals, Total	Manganese	0.23	mg/L		0.075	0.075	BKG
Unconsolidated	WBGmw-006	6/21/2022	WBGmw-006-220601-GW	Grab	Explosives/Propellants	RDX	6.9	ug/L			0.97	RSL
Unconsolidated	WBGmw-009	6/21/2022	WBGmw-009-220601-GW	Grab	Explosives/Propellants	RDX	1.3	ug/L			0.97	RSL
Unconsolidated	LL1mw-086	6/24/2022	LL1mw-086-220601-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	1.3	ug/L			0.98	RSL
Unconsolidated	LL1mw-086	6/24/2022	LL1mw-086-220601-GW	Grab	Explosives/Propellants	RDX	1.1	ug/L			0.97	RSL
Unconsolidated	LL12mw-185	6/27/2022	LL12mw-185-220601-GW	Grab	Anions	Nitrate	71	mg/L			10	MCL
Unconsolidated	LL12mw-185	6/27/2022	LL12mw-185-220602-GW	Field Duplicate	Anions	Nitrate	74	mg/L			10	MCL
Upper Sharon	LL1mw-080	6/23/2022	LL1mw-080-220601-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	4.9	ug/L			3.9	RSL
Upper Sharon	LL1mw-080	6/23/2022	LL1mw-080-220601-GW	Grab	Explosives/Propellants	RDX	26	ug/L			0.97	RSL
Upper Sharon	LL1mw-081	6/23/2022	LL1mw-081-220601-GW	Grab	Explosives/Propellants	RDX	1	ug/L	J		0.97	RSL
Upper Sharon	LL1mw-083	6/17/2022	LL1mw-083-220601-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	1.9	ug/L			0.98	RSL
Upper Sharon	LL1mw-083	6/17/2022	LL1mw-083-220601-GW	Grab	Explosives/Propellants	2,4-Dinitrotoluene	2.5	ug/L			0.24	RSL
Upper Sharon	LL1mw-083	6/17/2022	LL1mw-083-220601-GW	Grab	Explosives/Propellants	2,6-Dinitrotoluene	1	ug/L			0.122	RA
Upper Sharon	LL1mw-083	6/17/2022	LL1mw-083-220601-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	8.5	ug/L			3.9	RSL
Upper Sharon	LL1mw-083	6/17/2022	LL1mw-083-220601-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	16	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220601-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	2.7	ug/L			0.98	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220602-GW	Field Duplicate	Explosives/Propellants	2,4,6-Trinitrotoluene	2.9	ug/L			0.98	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220601-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	7.7	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220602-GW	Field Duplicate	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	7.8	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220601-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	23	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	6/17/2022	LL1mw-084-220602-GW	Field Duplicate	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	24	ug/L			3.9	RSL
Upper Sharon	LL3mw-237	6/24/2022	LL3mw-237-220601-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	42	ug/L	J		0.98	RSL
Upper Sharon	LL3mw-237	6/24/2022	LL3mw-237-220601-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	6.9	ug/L			3.9	RSL
Upper Sharon	LL3mw-237	6/24/2022	LL3mw-237-220601-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	27	ug/L	J		3.9	RSL
Upper Sharon	LL3mw-237	6/24/2022	LL3mw-237-220601-GW	Grab	Explosives/Propellants	RDX	6.7	ug/L			0.97	RSL

µg/L = Micrograms per Liter
BKG = Background
GW = Groundwater
ID = Identifier
J = Result is estimated
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
N/A = Not Applicable
RA = Resident Adult Facility-wide Cleanup Goal
RDX = Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RSL = Regional Screening Level

Table 6-3. Screening Level Exceedances – Fall 2022 Sample Event

Zone	Well	Date Collected	Sample ID	Sample Type	Analysis Type	Chemical	Result	Units	Validation Qual	Background Criteria	GW Screening Level	GW Screening Criteria Source
Homewood	FBQmw-173	10/4/2022	FBQmw-173-220901-GW	Grab	Explosives/Propellants	2-Nitrotoluene	0.49	ug/L	J		0.37	RA
Unconsolidated	DETmw-003	10/5/2022	DET-003-220902-GW	Field Duplicate	Metals, Total	Arsenic	0.012	mg/L		0.003	0.01	MCL
Unconsolidated	DETmw-003	10/5/2022	DET-003-220901-GW	Grab	Metals, Total	Arsenic	0.011	mg/L		0.003	0.01	MCL
Unconsolidated	DETmw-003	10/5/2022	DET-003-220902-GW	Field Duplicate	Metals, Total	Manganese	0.25	mg/L		0.075	0.075	BKG
Unconsolidated	DETmw-003	10/5/2022	DET-003-220901-GW	Grab	Metals, Total	Manganese	0.25	mg/L		0.075	0.075	BKG
Unconsolidated	DETmw-004	10/5/2022	DET-004-220901-GW	Grab	Metals, Total	Manganese	0.2	mg/L		0.075	0.075	BKG
Unconsolidated	WBGmw-006	9/30/2022	WBGmw-006-220901-GW	Grab	Explosives/Propellants	RDX	7.2	ug/L			0.97	RSL
Unconsolidated	WBGmw-009	9/30/2022	WBGmw-009-220901-GW	Grab	Explosives/Propellants	RDX	3.5	ug/L			0.97	RSL
Upper Sharon	LL1mw-083	9/27/2022	LL1mw-083-220901-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	2.4	ug/L			0.98	RSL
Upper Sharon	LL1mw-083	9/27/2022	LL1mw-083-220901-GW	Grab	Explosives/Propellants	2,4-Dinitrotoluene	2.9	ug/L			0.24	RSL
Upper Sharon	LL1mw-083	9/27/2022	LL1mw-083-220901-GW	Grab	Explosives/Propellants	2,6-Dinitrotoluene	1.7	ug/L			0.122	RA
Upper Sharon	LL1mw-083	9/27/2022	LL1mw-083-220901-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	9.6	ug/L			3.9	RSL
Upper Sharon	LL1mw-083	9/27/2022	LL1mw-083-220901-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	14	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220901-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	2.5	ug/L	J		0.98	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220902-GW	Field Duplicate	Explosives/Propellants	2,4,6-Trinitrotoluene	2.9	ug/L			0.98	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220901-GW	Grab	Explosives/Propellants	2,4-Dinitrotoluene	1.6	ug/L	J		0.24	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220902-GW	Field Duplicate	Explosives/Propellants	2,4-Dinitrotoluene	2	ug/L			0.24	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220901-GW	Grab	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	6.1	ug/L	J		3.9	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220902-GW	Field Duplicate	Explosives/Propellants	2-Amino-4,6-Dinitrotoluene	7.3	ug/L			3.9	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220901-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	15	ug/L	J		3.9	RSL
Upper Sharon	LL1mw-084	9/27/2022	LL1mw-084-220902-GW	Field Duplicate	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	18	ug/L			3.9	RSL
Upper Sharon	LL2mw-059	9/29/2022	LL2mw-059-220901-GW	Grab	Explosives/Propellants	2,4-Dinitrotoluene	0.35	ug/L			0.24	RSL
Upper Sharon	LL3mw-238	9/29/2022	LL3mw-238-220901-GW	Grab	Explosives/Propellants	2,4,6-Trinitrotoluene	28	ug/L	J		0.98	RSL
Upper Sharon	LL3mw-238	9/29/2022	LL3mw-238-220901-GW	Grab	Explosives/Propellants	4-Amino-2,6-Dinitrotoluene	28	ug/L			3.9	RSL
Upper Sharon	LL3mw-238	9/29/2022	LL3mw-238-220901-GW	Grab	Explosives/Propellants	RDX	3.4	ug/L			0.97	RSL
Unconsolidated	LL12mw-185	6/27/2022	LL12mw-185-220601-GW	Grab	Anions	Nitrate	71	mg/L	J		10	MCL
Unconsolidated	LL12mw-185	6/27/2022	LL12mw-185-220602-GW	Field Duplicate	Anions	Nitrate	74	mg/L			10	MCL
Unconsolidated	LL12mw-185	9/30/2022	LL12mw-185-220901-GW	Grab	Anions	Nitrate	61	mg/L	J		10	MCL
Unconsolidated	LL12mw-185	9/30/2022	LL12mw-185-220902-GW	Field Duplicate	Anions	Nitrate	62	mg/L	U		10	MCL
Unconsolidated	LL12mw-187	9/30/2022	LL12mw-187-220901-GW	Grab	Anions	Nitrate	1600	mg/L	J		10	MCL

µg/L = Micrograms per Liter
BKG = Background
GW = Groundwater
ID = Identifier
J = Result is estimated
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
RA = Resident Adult
RC = Resident Child Facility-wide Cleanup Goal
RDX = Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RSL = Regional Screening Level

Table 6-4. pH Levels Outside the Normal Range in 2022

Aquifer	Well ID	Spring 2022		Fall 2022	
		Date Sampled	pH	Date Sampled	pH
Unconsolidated	LL1mw-063	6/17/2022	4.67	9/28/2022	NM
Unconsolidated	FWGmw-010	6/14/2022	4.50	9/28/2022	5.08
Unconsolidated	LL1mw-089	6/14/2022	4.55	9/28/2022	5.10
Homewood	FBQmw-174	6/28/2022	4.88	Not Sampled	NM
Upper Sharon	LL1mw-083	6/17/2022	4.17	9/27/2022	4.41

ID = Identifier
NM = Not Measured, well purged dry

THIS PAGE INTENTIONALLY LEFT BLANK.

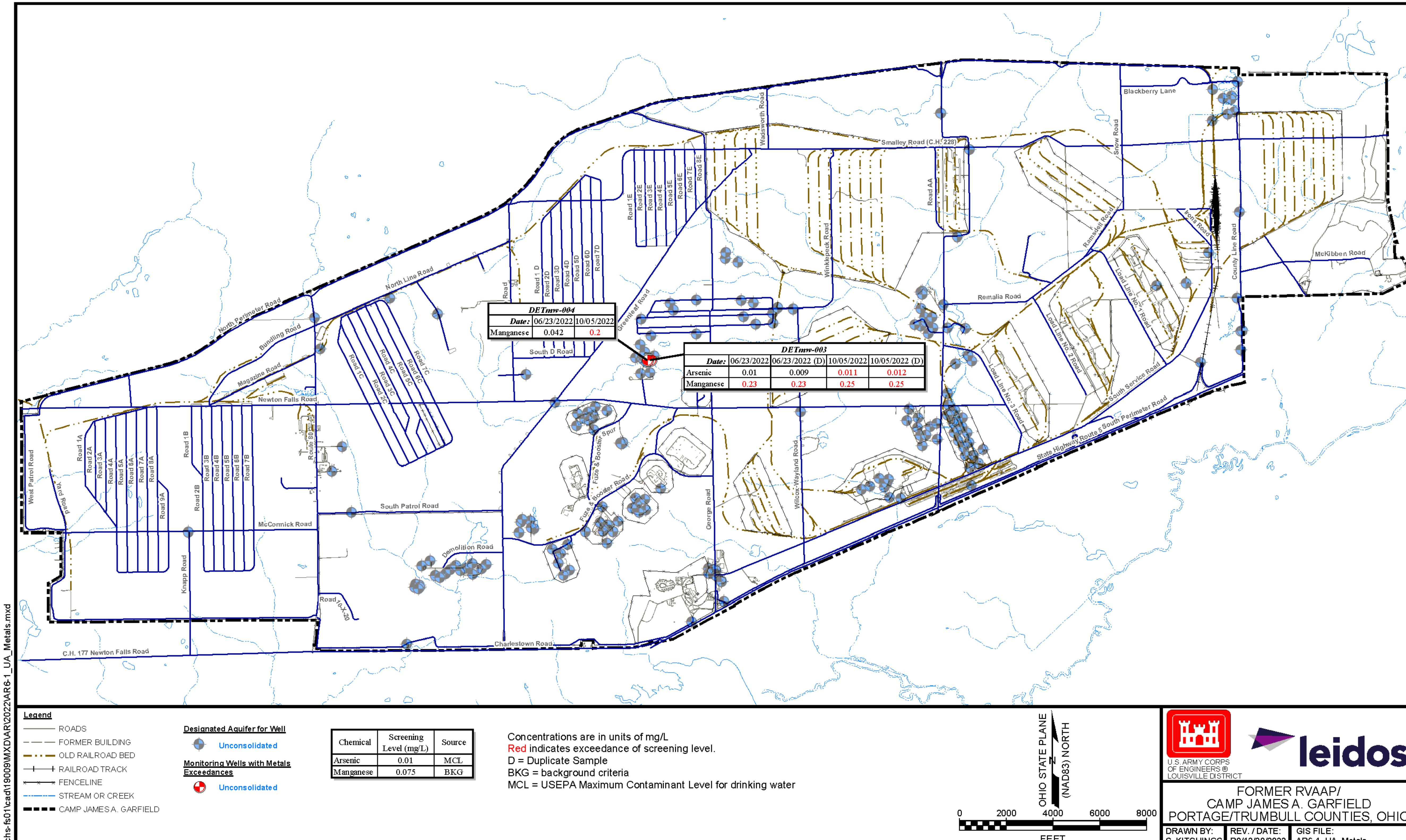


Figure 6-1. Inorganic Exceedances in the Unconsolidated Aquifer

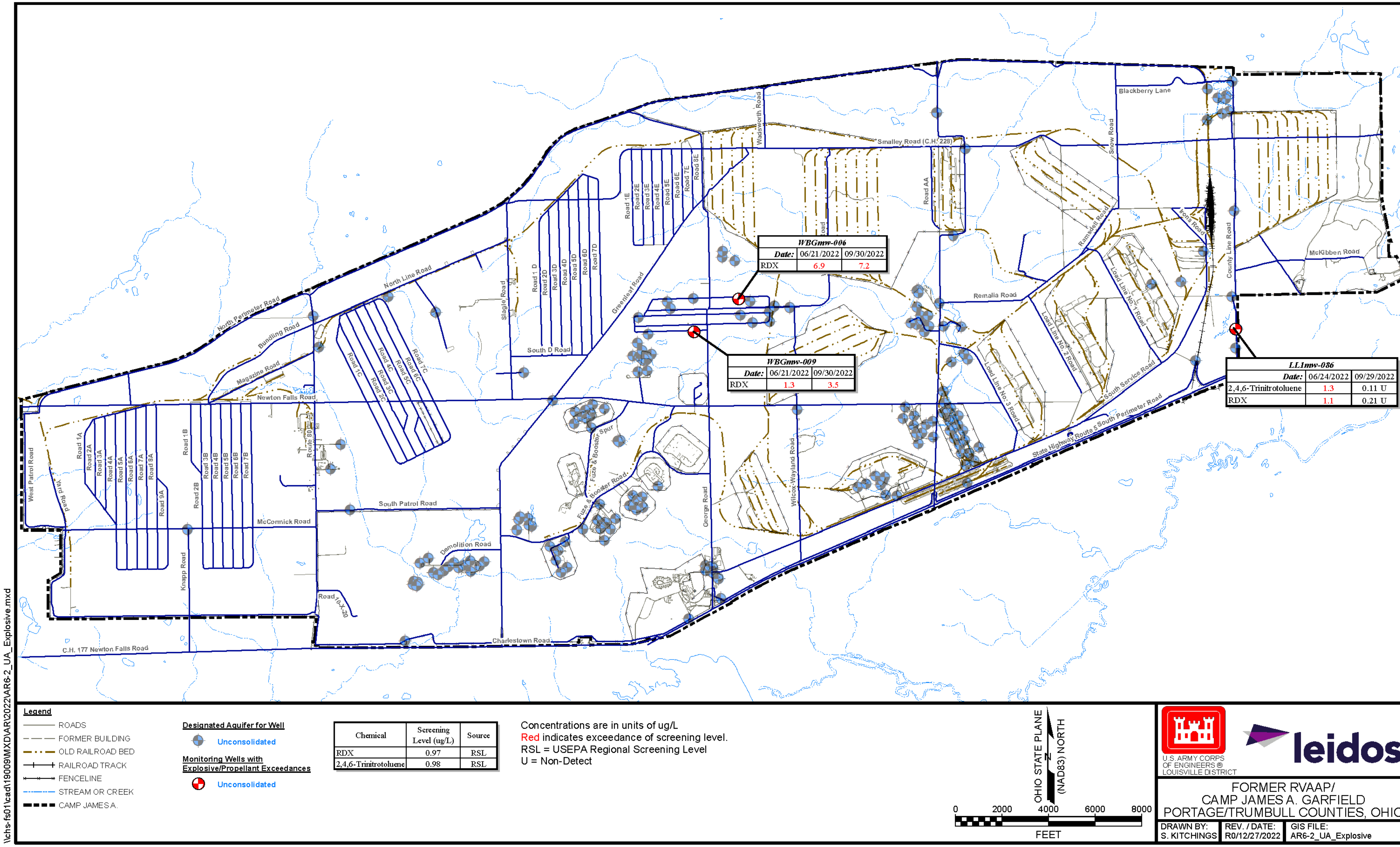
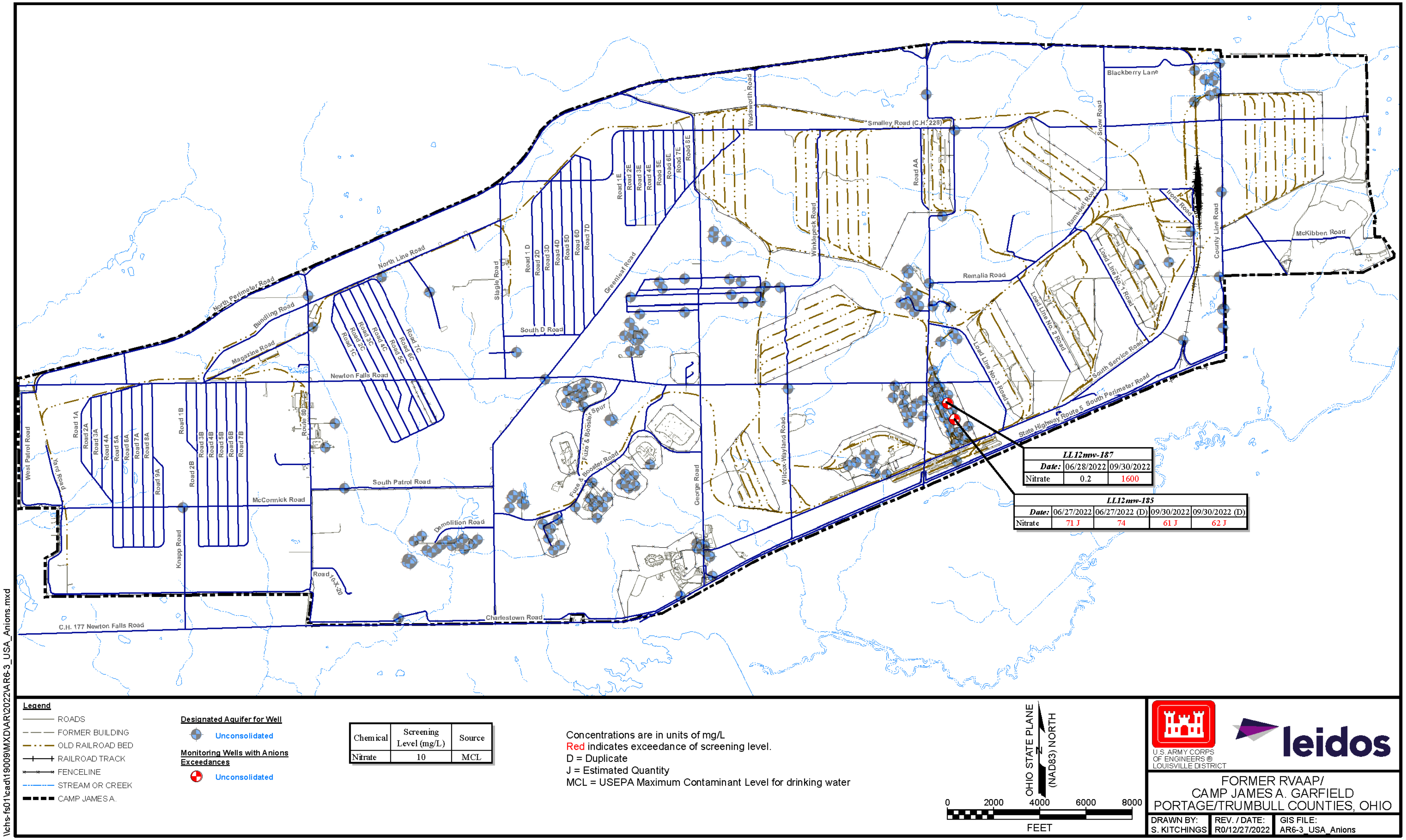


Figure 6-2. Explosive/Propellant Exceedances in the Unconsolidated Aquifer

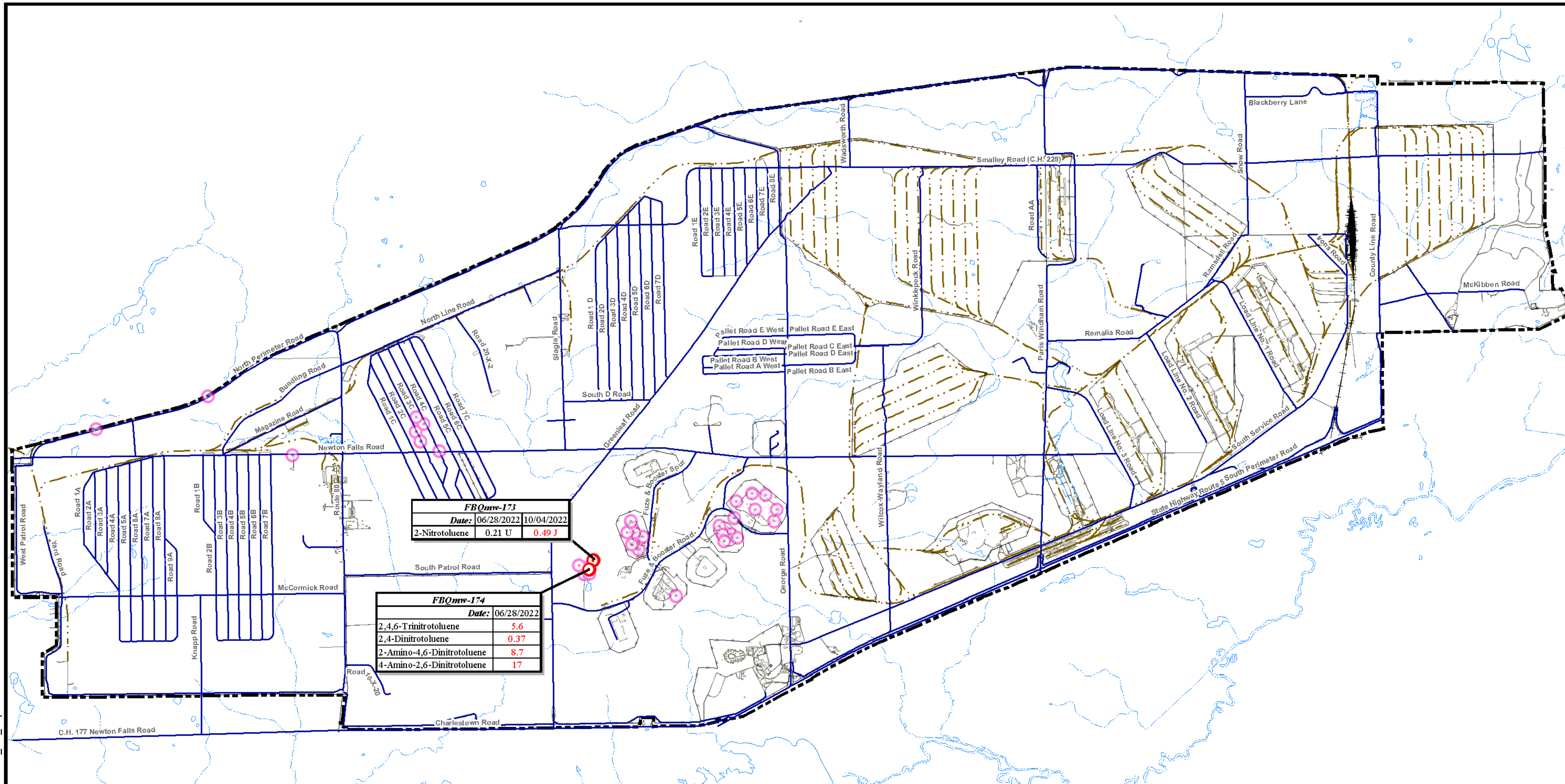


LL12mw-187		
Date:	06/28/2022	09/30/2022
Nitrate	0.2	1600

LL12mw-185				
Date:	06/27/2022	06/27/2022 (D)	09/30/2022	09/30/2022 (D)
Nitrate	71 J	74	61 J	62 J

Chemical	Screening Level (mg/L)	Source
Nitrate	10	MCL

Figure 6-3. Anion Exceedances in the Upper Sharon Aquifer



FBQmw-173		
Date:	06/28/2022	10/04/2022
2-Nitrotoluene	0.21 U	0.49 J

FBQmw-174	
Date:	06/28/2022
2,4,6-Trinitrotoluene	5.6
2,4-Dinitrotoluene	0.37
2-Amino-4,6-Dinitrotoluene	8.7
4-Amino-2,6-Dinitrotoluene	17

Legend

- ROADS
- FORMER BUILDING
- OLD RAILROAD BED
- RAILROAD TRACK
- FENCELINE
- STREAM OR CREEK
- CAMP JAMES A. GARFIELD

Designated Aquifer for Well

- Homewood Sandstone

Monitoring Wells with Explosive/Propellant Exceedances

- Homewood Sandstone

Chemical	Screening Level (ug/L)	Source
2,4,6-Trinitrotoluene	0.98	RSL
2,4-Dinitrotoluene	0.24	RSL
2-Amino-4,6-Dinitrotoluene	3.9	RSL
4-Amino-2,6-Dinitrotoluene	3.9	RSL
2-Nitrotoluene	0.37	RA

Concentrations are in units of ug/L
Red indicates exceedance of screening level.
J = estimated result
U = Non-Detect
RA = Resident Adult Facility-wide Cleanup Goal
RSL = USEPA Regional Screening Level

OHIO STATE PLANE (NAD83) NORTH

0 2000 4000 6000 8000
FEET

U.S. ARMY CORPS OF ENGINEERS® LOUISVILLE DISTRICT

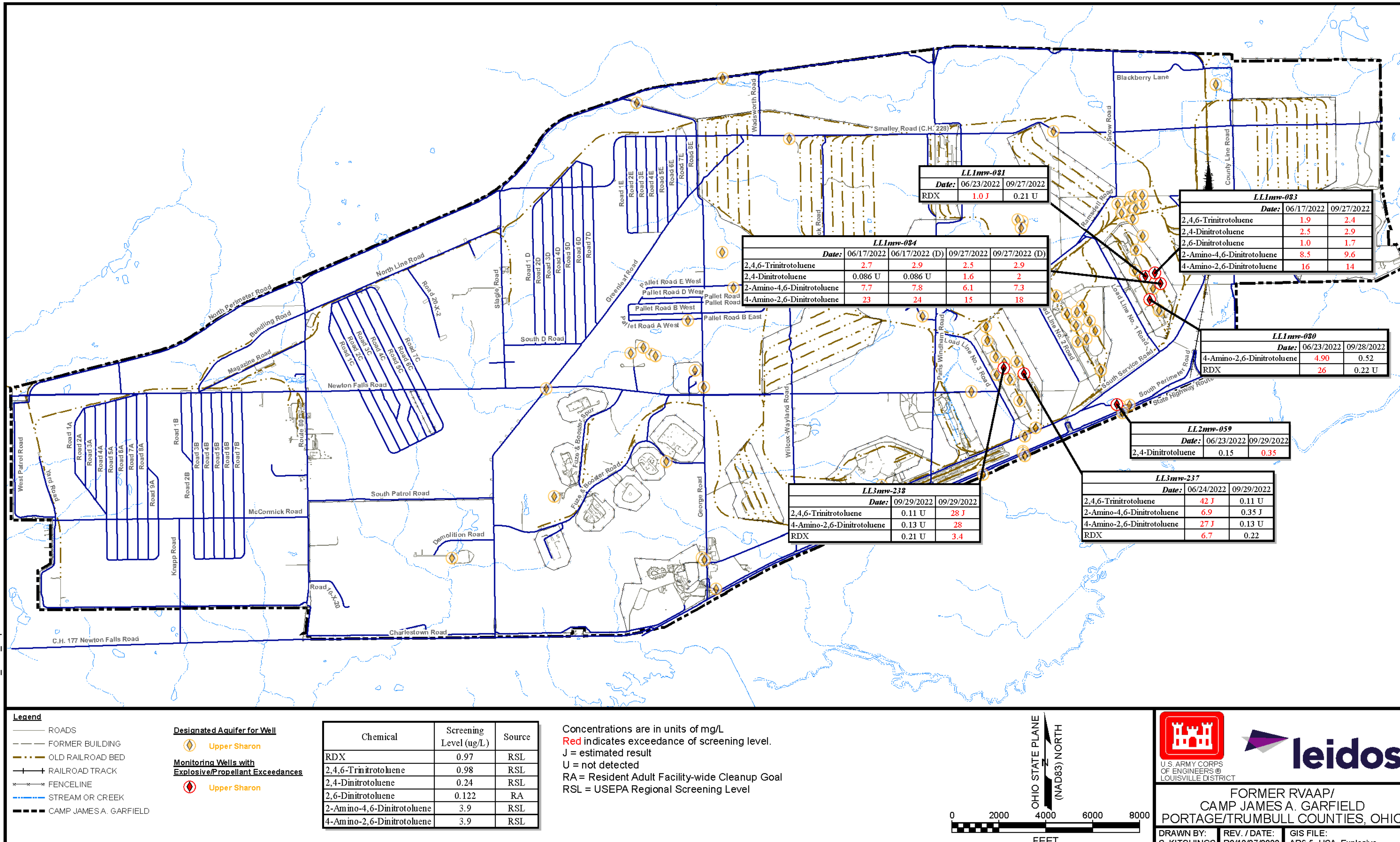
leidos

FORMER RVAAP/
CAMP JAMES A. GARFIELD
PORTAGE/TRUMBULL COUNTIES, OHIO

DRAWN BY: S. KITCHINGS | REV. / DATE: R0/12/20/2022 | GIS FILE: AR6-4_HA_Explosive

\\chs-fs01\cad\19009\MXD\AR\2022\AR6-4_HA_Explosive.mxd

Figure 6-4. Explosive/Propellant Exceedances in the Homewood Aquifer



LL1mw-081		
Date:	06/23/2022	09/27/2022
RDX	1.0 J	0.21 U

LL1mw-083		
Date:	06/17/2022	09/27/2022
2,4,6-Trinitrotoluene	1.9	2.4
2,4-Dinitrotoluene	2.5	2.9
2,6-Dinitrotoluene	1.0	1.7
2-Amino-4,6-Dinitrotoluene	8.5	9.6
4-Amino-2,6-Dinitrotoluene	16	14

LL1mw-084				
Date:	06/17/2022	06/17/2022 (D)	09/27/2022	09/27/2022 (D)
2,4,6-Trinitrotoluene	2.7	2.9	2.5	2.9
2,4-Dinitrotoluene	0.086 U	0.086 U	1.6	2
2-Amino-4,6-Dinitrotoluene	7.7	7.8	6.1	7.3
4-Amino-2,6-Dinitrotoluene	23	24	15	18

LL1mw-080		
Date:	06/23/2022	09/28/2022
4-Amino-2,6-Dinitrotoluene	4.90	0.52
RDX	26	0.22 U

LL2mw-059		
Date:	06/23/2022	09/29/2022
2,4-Dinitrotoluene	0.15	0.35

LL3mw-238		
Date:	09/29/2022	09/29/2022
2,4,6-Trinitrotoluene	0.11 U	28 J
4-Amino-2,6-Dinitrotoluene	0.13 U	28
RDX	0.21 U	3.4

LL3mw-237		
Date:	06/24/2022	09/29/2022
2,4,6-Trinitrotoluene	42 J	0.11 U
2-Amino-4,6-Dinitrotoluene	6.9	0.35 J
4-Amino-2,6-Dinitrotoluene	27 J	0.13 U
RDX	6.7	0.22

Chemical	Screening Level (ug/L)	Source
RDX	0.97	RSL
2,4,6-Trinitrotoluene	0.98	RSL
2,4-Dinitrotoluene	0.24	RSL
2,6-Dinitrotoluene	0.122	RA
2-Amino-4,6-Dinitrotoluene	3.9	RSL
4-Amino-2,6-Dinitrotoluene	3.9	RSL

Figure 6-5. Explosive/Propellant Exceedances in the Upper Sharon Aquifer

THIS PAGE INTENTIONALLY LEFT BLANK.

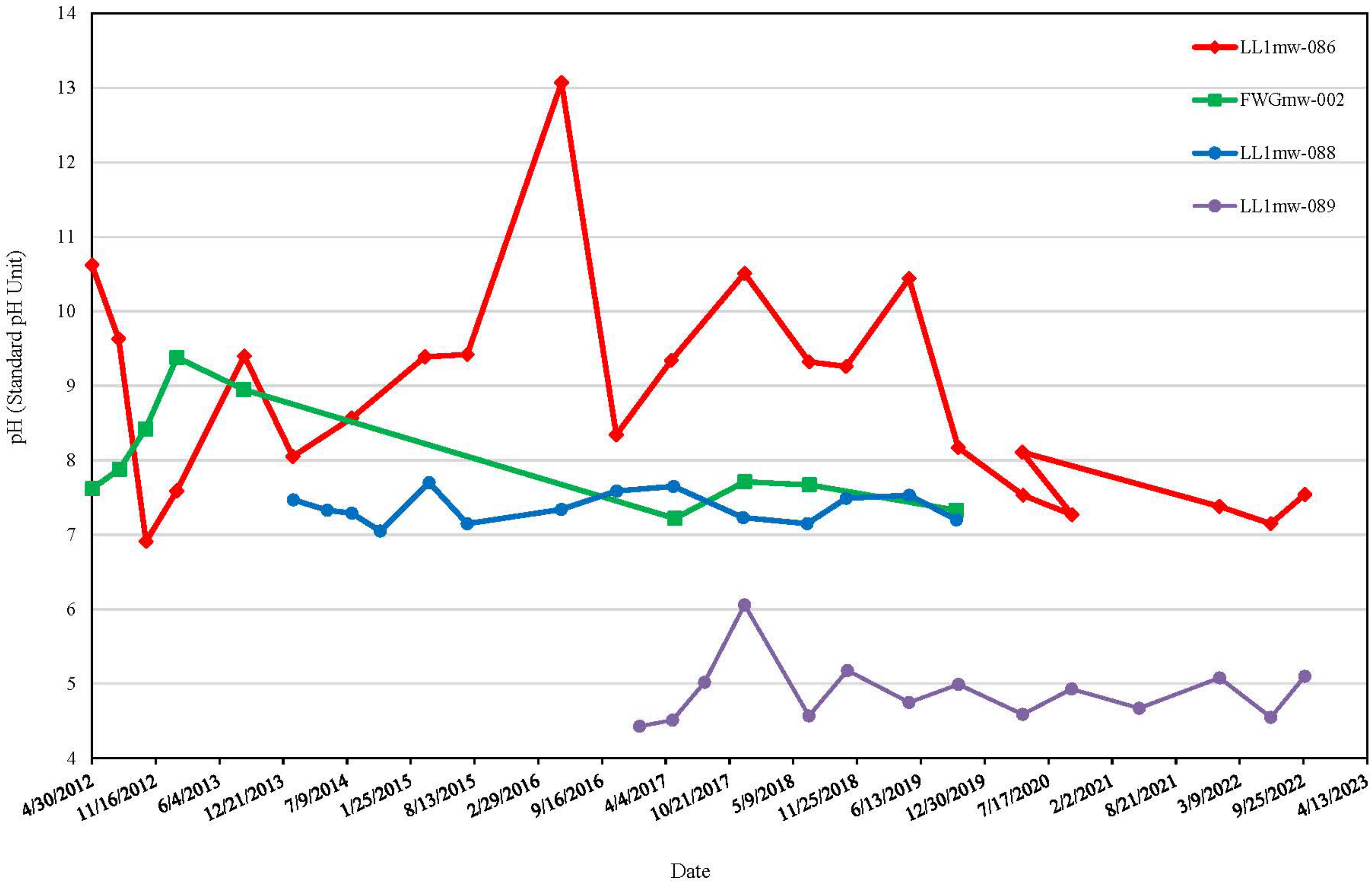


Figure 6-6. FWGmw-002, LL1mw-086, LL1mw-088, and LL1mw-089 pH – Unconsolidated Aquifer

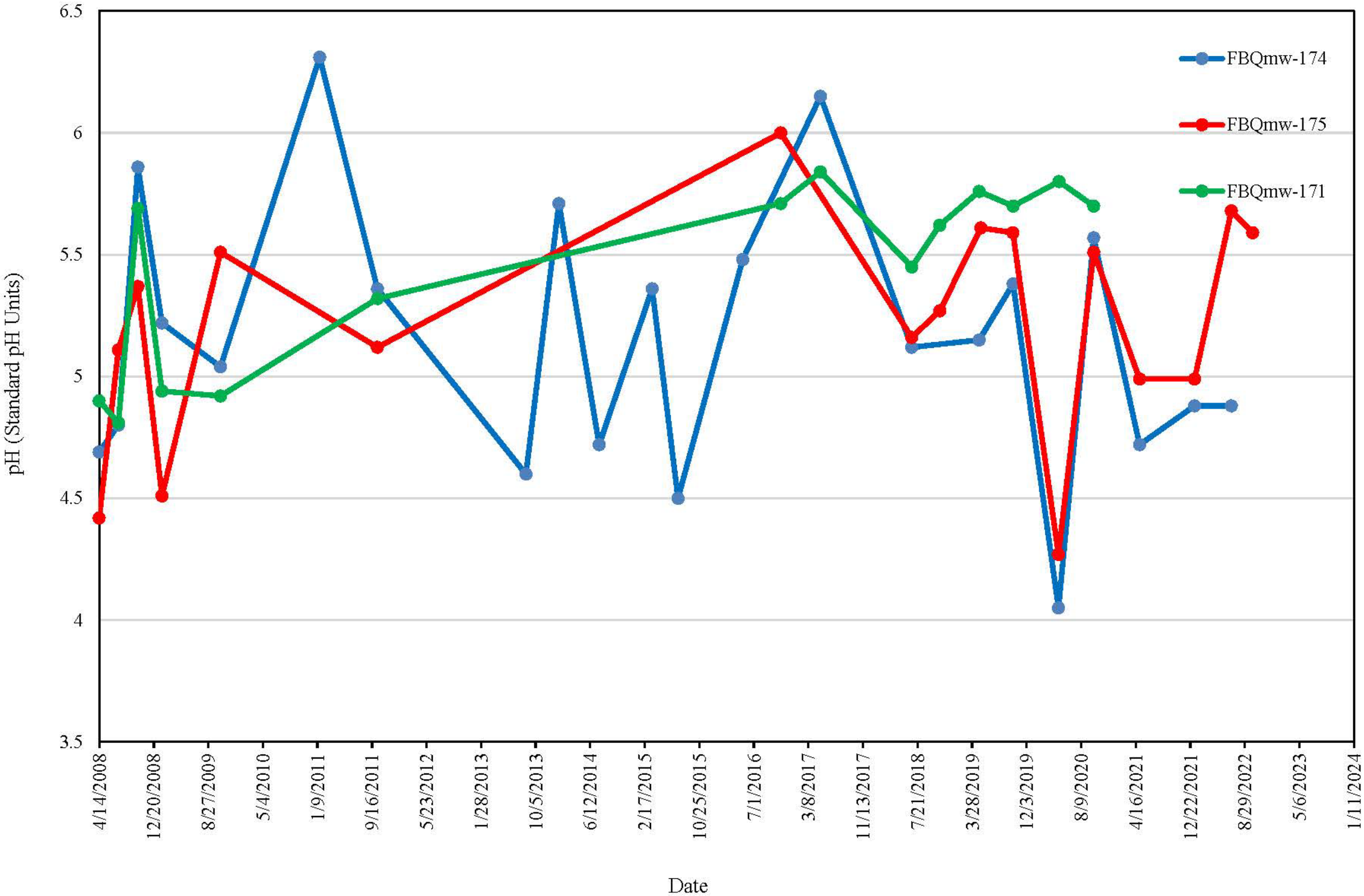


Figure 6-7. Fuze and Booster Quarry Landfill/Ponds pH – Homewood Aquifer

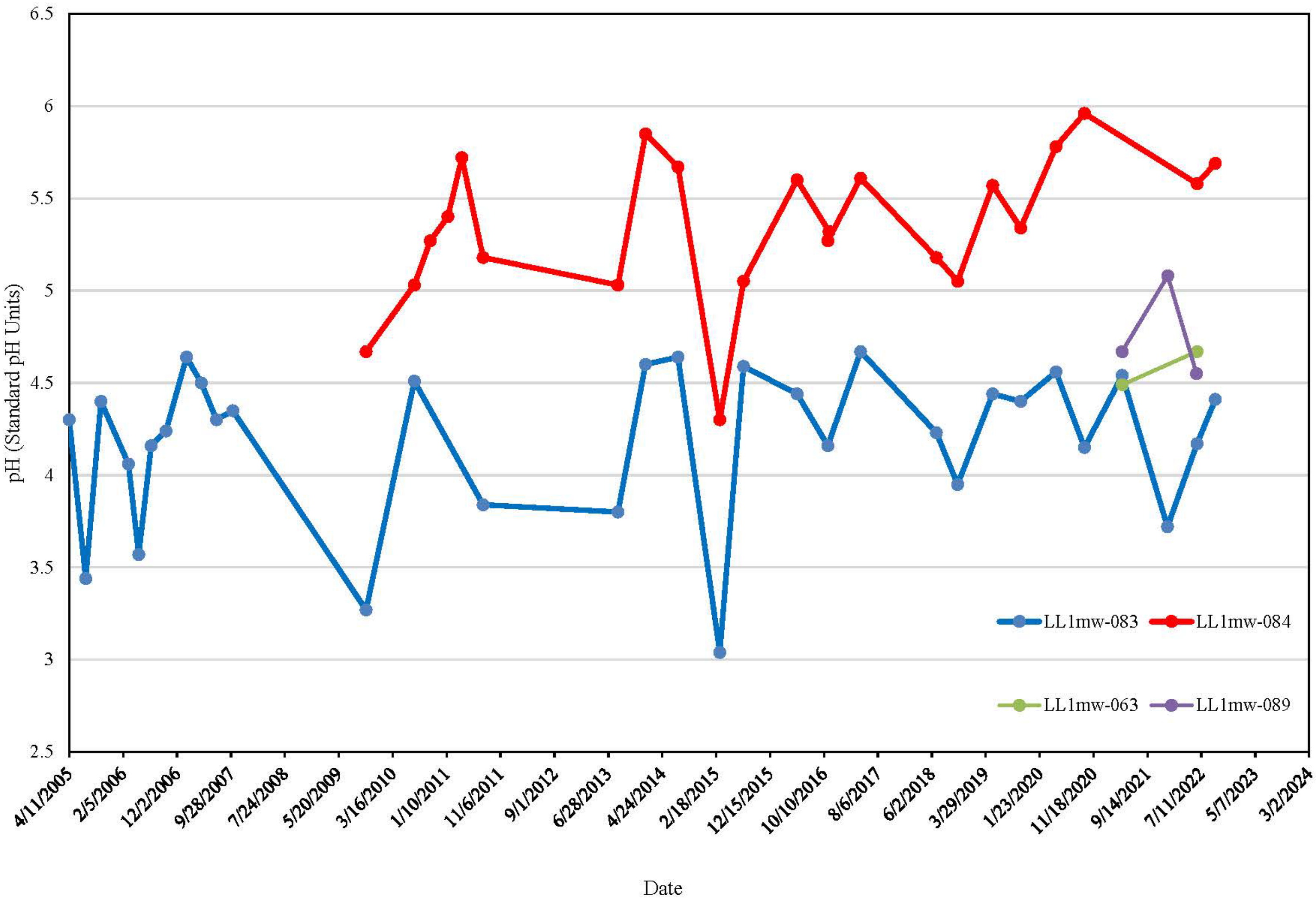


Figure 6-8. Load Line 1 pH – Upper Sharon Aquifer

THIS PAGE INTENTIONALLY LEFT BLANK.

7.0 TIME-TREND GRAPHS

Time-trend graphs presented in the FWGW RI Report (Leidos 2022b) are updated in this report to present 2022 data. Concentrations of the constituents were graphed by monitoring well and chemical. The graphs include linear trendlines for each chemical. Non-detect results are included in the graphs and are plotted as the reporting limit. Appendix I includes the graphs. The following subsections summarize the findings of the graphs.

7.1 EXPLOSIVES AND PROPELLANTS

Explosives or propellants were detected in 20 of 40 wells sampled for explosives in 2022 and only exceeded the screening level in 12 wells. The time-trend graphs in Appendix I indicate that in most of the monitoring wells where exceedances were detected in 2022, the concentration is decreasing or remaining the same. The trendlines provided in Appendix I are summarized below:

- FBQmw-174
  - 2,4-DNT – The slightly upward trendline is a result of the May 2017 sample, which was considered non-detect but was reported at a concentration of 2.2 µg/L. Without this data point, the trendline is downward. 2,4-DNT concentrations after the May 2017 concentration are significantly less than 2.2 µg/L. 2,4-DNT was detected at a concentration of 0.37 µg/L, slightly above the detection limit, in Spring 2022 (Figure I-1).
  - 2-Amino-4,6-DNT and 4-Amino-2,6-DNT – The trendlines show decreasing groundwater concentrations. 2-Amino-4,6-DNT and 4-amino-2,6-DNT were detected at concentrations exceeding screening criteria in the most recent samples from Spring 2022, above the non-detect sample concentrations in Fall 2019 (Figures I-2 and I 3).
  - TNT – The trendline shows decreasing groundwater concentrations. The Spring 2022 sample exceeded the screening criteria at a concentration of 5.6 µg/L (Figure I-4).

FBQmw-174 was dry during the Fall 2022 sampling event. Therefore, only Spring data have been discussed in this report and added to the trendline graphs in Appendix I. The trendlines provided in Appendix I are summarized below:

- LL1mw-080
  - 2-Amino-4,6-DNT and 4-amino-2,6-DNT – Except for 4-Amino-2,6-DNT, which most recently exceeded the screening criteria in Spring 2022 at a concentration of 4.9 µg/L, the trendlines have been below the current screening levels since Fall 2016. The trendlines for groundwater concentration have been continuously decreasing (Figures I-5 and I-6).
  - RDX – Based on the trendline, groundwater concentrations have been decreasing. However, concentrations remain above the screening level except for in the most recent sample collected in Fall 2022, which was below the detection limit (Figure I-7).
- LL1mw-083
  - 1,3-DNB (Dinitrobenzene) – The trendline shows slightly increased groundwater concentrations due to the high concentrations detected in 2019 through 2021, above the screening level of 0.2 µg/L. Samples from 2020 and 2021 are below the concentration of

the Spring 2019 sample but are still above the screening level except for the Spring 2021 sample (0.098 UJ µg/L). Both samples collected in 2022 were below the detection limit. Since 2010, 6 of 20 samples have been below the screening level of 0.2 µg/L (Figure I-8).

  - All other explosive (2-amino-4,6-DNT, 4-amino-2,6-DNT, TNT, 2,4-DNT, and 2,6-DNT) trendlines for LL1mw 083 show decreasing groundwater concentrations, even with the four most recent sampling events with concentrations above the respective screening levels (Figures I-9 to I-13).

- LL1mw-084
  - 1,3-DNB – The trendline shows slightly decreasing groundwater concentrations. The highest concentration was detected during the Fall 2019 sampling event. The most recent Fall 2022 sample is below the detection level at 0.11 U µg/L (Figure I-14).
  - RDX – The overall trendline shows slightly decreasing groundwater concentrations. RDX was detected at the highest concentration of 5.2 µg/L during the October 2018 sampling event. The concentrations of RDX were below the detection level in the Spring 2022 sample at 0.22 U µg/L (Figure I-15).
  - 2,6-DNT – The trendline has been historically above the screening level of 0.122 µg/L. However, since Fall 2020, concentrations have been below the screening level (Figure I-20).
  - The trendlines for all other explosives (2-amino-4,6-DNT, 4-amino-2,6-DNT, TNT, and 2,4-DNT) show decreasing groundwater concentrations. 2,4 DNT concentrations remain above the respective screening levels except for the concentration of 0.086 U µg/L detected in the Spring 2022 sample (Figures I-16 to I-19).
- LL2mw-059
  - 1,3-DNB – The trendline shows slightly decreasing groundwater concentrations, with 28-of 39 reported concentrations below the screening level. The most recent concentrations from the 2022 sampling events are below the screening level (Figure I-21).
  - 2,4-DNT – The trendline shows increasing groundwater concentrations. The sample collected in Spring 2022 was detected at a concentration of 0.15 µg/L, below the screening level, and the sample collected in Fall 2022 was detected at a concentration of 0.35 µg/L, which exceeded the screening level (Figure I-22).
- LL3mw-237
  - 2-Amino-4,6-DNT – The trendline shows decreasing concentrations in groundwater. However, the sample collected in Spring 2022 was detected at a concentration of 6.9 µg/L, which is the highest concentration since semi-annual monitoring began in 2016 (Figure I-23).
  - 4-Amino-2,6-DNT – The trendline shows slightly increasing concentrations in groundwater. The sample collected in Spring 2022 was detected at a concentration of 27 µg/L, which is the highest concentration since monitoring began in 2001 (Figure I-24).
- LL3mw-238
  - All trendlines for explosives (2-amino-4,6-DNT, 4-amino-2,6-DNT, TNT, 2,6-DNT, and RDX) show decreasing groundwater concentrations. TNT, 4-amino-2,6-DNT, and RDX concentrations remain above the respective screening levels except for non-detects in Spring 2022 (Figures I-25 to I-29).

- LL3mw-239
    - RDX – The trendline shows decreasing groundwater concentrations. The most recent samples are below both the Fall 2016 sample concentration and the screening level (Figure I-30).
- LL3mw-241
    - TNT and RDX – The trendlines show decreasing groundwater concentrations. The most recent samples from 2022 are below screening levels (Figures I-31 and I-32).
- WBGmw-006
    - RDX – The trendline shows decreasing groundwater concentrations. but concentrations remain above the screening level (Figure I-33).
- WBGmw-009
    - RDX – The trendline shows decreasing groundwater concentrations, but concentrations remain above the screening level (Figure I-34).

7.2 SEMIVOLATILE ORGANIC COMPOUNDS

SVOCs were not detected in the two (DETmw-003 and DETmw-004) semi-annual wells that were sampled for SVOCs during the 2022 sampling events.

7.3 VOLATILE ORGANIC COMPOUNDS

VOCs were detected in one (LL10mw-003) of the three wells sampled for VOCs during the 2022 sampling events. VOCs did not exceed the screening criteria in either sampling event of 2022.

Carbon tetrachloride was detected in both 2022 samples collected at LL10mw-003; however, both samples were below the MCL of 5 µg/L. A trend analysis is provided in Figure I-35 showing carbon tetrachloride concentrations at the Load Line 10 monitoring wells.

7.4 PESTICIDES AND POLYCHLORINATED BIPHENYLS

No pesticides or PCBs were detected in any of the four groundwater samples collected in 2022. Consequently, trend analysis and graphs are not provided for pesticides or PCBs.

7.5 CYANIDE

No cyanide was detected in either of the two groundwater samples collected in 2022. Consequently, trend analysis and graphs are not provided for cyanide.

THIS PAGE INTENTIONALLY LEFT BLANK.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the work completed and the pertinent findings from the 2022 FWGWMP monitoring events conducted at CJAG. The recommendations indicate future activities to be performed regarding groundwater monitoring.

8.1 CONCLUSIONS

FWGWMP sampling events were conducted in Spring and Fall 2022. These sampling events were conducted in accordance with the objectives specified in the 2022 Addendum (Leidos 2022a) and applicable FCRs. Table 8-1 presents the wells and rationale list, which is provided in Table 3-3 of the 2022 Addendum (Leidos 2022a) and includes a column that presents the results and findings from the analyses conducted at each well.

The annual water level measurements were collected in October 2022. Groundwater elevations from 317 monitoring wells were used to generate the potentiometric surfaces for the Unconsolidated, Homewood Sandstone, Upper Sharon Sandstone, and Basal Sharon Conglomerate aquifers.

In general, the groundwater elevations observed during the October 2022 gauging event were similar to those observed during the December 2021 event. The primary gradient for the Unconsolidated aquifer was toward the east, with localized variances toward the north and south, as well as localized radial flow. The primary gradient for the Homewood aquifer was toward the east/southeast, with a localized radial pattern near Load Line 9 and Fuze and Booster Quarry. The primary gradient of the Upper Sharon aquifer was toward the east/southeast/northeast, with a localized radial pattern near Load Line 2. The primary gradient for the Basal Sharon Conglomerate aquifer was directed toward the east, with a northeasterly trend in the northeastern portion of CJAG.

8.2 RECOMMENDATIONS

The following subsections present recommendations of activities to be performed during the FWGWMP.

8.2.1 Well Redevelopment

As part of the ongoing FWGW monitoring, wells will be considered for redevelopment to remove accumulated sediment and fines from the filter packs. Wells to be considered for redevelopment prior to sampling are LL1mw-064, LL1mw-086, and LL12mw-244.

8.2.2 2023 FWGWMP Sampling

The proposed FWGWMP groundwater sampling for 2023 is provided in the 2023 Addendum (Leidos 2023).

THIS PAGE INTENTIONALLY LEFT BLANK.

Table 8-1. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
1	RVAAP-04 Open Demolition Area #2	DETmw-003	Unconsolidated	In accordance with the DFFO, analytical parameters for this well in 2022 include VOCs, phthalates, PAHs, phenols, PCBs, explosives, pesticides, cyanide, and metals.	• Phthalates, phenol, cyanide, nitroaromatics, VOCs, SVOCs, PCBs, or pesticides were not detected in the primary or duplicate samples in Spring or Fall 2022. • Explosives were not detected in the primary or duplicate samples collected in 2022. • All metal concentrations were below the screening level or background concentration, with the exceptions of arsenic, barium, beryllium, thallium, silver, and manganese. Arsenic was detected in the primary and duplicate samples at 0.0095 and 0.0092 mg/L in Spring 2022, respectively, exceeding the background concentration of 0.003 mg/L. Arsenic was detected in the primary and duplicate samples at 0.012 and 0.011 mg/L, respectively, in Fall 2022, exceeding the background concentration of 0.003 mg/L. Barium was detected at 0.045 mg/L in both the primary and duplicate samples in Spring 2022, exceeding the background concentration of 0.034 mg/L. Barium was detected in the primary and duplicate samples at 0.049 and 0.05 mg/L, respectively, in Fall 2022, exceeding the background concentration of 0.034 mg/L. Manganese was detected at a concentration of 0.23 mg/L in both the primary and duplicate samples in Spring 2022, exceeding the background concentration of 0.075 mg/L. Manganese was detected in the primary and duplicate sample at 0.25 mg/L in Fall 2022, exceeding the background concentration of 0.075 mg/L. Beryllium was detected in the duplicate sample at 0.0003J mg/L in Fall 2022. Thallium was detected in the primary and duplicate sample at 0.00011 and 0.003J mg/L, respectively, and silver was detected in the duplicate sample at 0.000033J mg/L in Fall 2022. • pH was 6.64 S.U. in Spring 2022 and 7.1 S.U. in Fall 2022.
2	RVAAP-04 Open Demolition Area #2	DETmw-004	Unconsolidated	In accordance with the DFFO, analytical parameters for this well in 2022 include VOCs, phthalates, PAHs, phenols, PCBs, explosives, pesticides, cyanide, and metals.	• VOCs, SVOCs, pesticides, phthalates, phenol nitroaromatics, cyanide, PAHs, and PCBs were not detected in Spring and Fall 2022. • All metal and explosive concentrations were below the screening level or background concentration with the exceptions of barium cadmium, manganese, calcium, thallium, and zinc. Barium was detected at 0.057 mg/L in Spring 2022 and 0.066 mg/L in Fall 2022; both concentrations exceed the background concentration of 0.034 mg/L. Calcium was detected at 130 mg/L in Spring and Fall 2022, which exceeds the background concentration of 107 mg/L. Cadmium was detected at 0.00045J mg/L in Spring 2022. Manganese was detected at 0.2 mg/L in Fall 2022, which exceeds the background concentration of 0.075 mg/L. Thallium was detected in Fall 2022 at 0.00011J mg/L. Zinc was detected at 0.012 mg/L in Spring 2022 and 0.032 mg/L in Fall 2022, which exceeds the background concentration of 0.005 mg/L. • pH was 6.87 S.U. in Spring 2022 and 6.61 S.U. in Fall 2022.
3	RVAAP-05 Winklepeck Burning Grounds	WBGmw-006	Unconsolidated	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• HMX, MNX, and RDX were the only explosives detected. RDX was detected at 0.0069 mg/L in Spring 2022, which exceeds the RSL of 0.00097 mg/L. HMX was detected at 3.3 µg/L in Fall 2022. RDX was detected at 0.0069 mg/L in Spring 2022 and 0.0072 mg/L in Fall 2022; both concentrations exceed the RSL of 0.00097 mg/L. MNX was detected at 0.0003 mg/L in Spring 2022. • Sulfide, nitrate, and nitrite were not detected in Spring or Fall 2022. • Sulfate was detected at 28 mg/L in Spring 2022 and 27 mg/L in Fall 2022. • Alkalinity was detected at 270 mg/L in Spring 2022 and 280 mg/L in Fall 2022. • TOC was detected at 1.4 mg/L in Spring 2022 and 0.79 mg/L in Fall 2022. • pH was 6.87 S.U. in Spring 2022 and 7.35 S.U. in Fall 2022.
4	RVAAP-05 Winklepeck Burning Grounds	WBGmw-009	Unconsolidated	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• HMX and RDX were the only explosives detected. RDX was detected at 0.0013 mg/L in Spring 2022 and 0.0035 mg/L in Fall 2022; both concentrations exceed the RSL of 0.00097 mg/L. HMX was detected at 0.00075 mg/L in Spring 2022 and 0.002 mg/L in Fall 2022. • Nitrate, nitrite, and sulfide were not detected. • Sulfate was detected at 16 mg/L in Spring 2022 and 19 mg/L in Fall 2022. • Alkalinity was detected at 110 mg/L in Spring 2022 and 320 mg/L in Fall 2022. • TOC was detected at 1.2 mg/L in Spring 2022 and 1.3 mg/L in Fall 2022. • pH was 5.61 S.U. in Spring 2022 and 7.02 S.U. in Fall 2022.
5	RVAAP-05 Winklepeck Burning Grounds	WBGmw-014	Unconsolidated	Monitor for explosives to support the FS.	• Explosives were not detected in Spring or Fall 2022. • pH was 7.24 S.U. in Spring 2022 and 7.18 in Fall 2022.

Table 8-1. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum (Continued)

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
6	RVAAP-05 Winklepeck Burning Grounds	WBGmw-016	Unconsolidated	Monitor for explosives to support the FS.	• Explosives were not detected in Spring or Fall 2022. • pH was 6.96 S.U. in Spring 2022 and 7.23 S.U. in Fall 2022.
7	RVAAP-05 Winklepeck Burning Grounds	WBGmw-017	Unconsolidated	Monitor for explosives to support the FS.	• Explosives were not detected in Spring or Fall 2022. • pH was 7.27 S.U. in Spring 2022 and 7.1 S.U. in Fall 2022.
8	RVAAP-05 Winklepeck Burning Grounds	WBGmw-018	Unconsolidated	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• RDX was the only explosive detected. RDX was detected at 0.2J mg/L in Spring 2022 and 0.25J ug/L in Fall 2022. No detection exceeded screening criteria in Spring or Fall 2022. • Nitrite and sulfide were not detected in Spring or Fall 2022. • Nitrate with detected at an estimated concentration of 0.23J mg/L in Spring 2022 and was not detected in Fall 2022. • Sulfate was detected at 9.9 mg/L in Spring 2022 and 10J mg/L in Fall 2022. • Alkalinity was detected at 46 mg/L in Spring and Fall 2022. • TOC was detected at 1.8 mg/L in Spring 2022 and 1.1 mg/L in Fall 2022. • pH was 5.50 S.U. in Spring 2022 and 5.71 in Fall 2022.
9	RVAAP-05 Winklepeck Burning Grounds	WBGmw-020	Upper Sharon	Continue to monitor for explosives.	• Explosives were not detected in Spring 2022. • 2-Nitrotoluene was the only explosive detected in Fall 2022. 2-Nitrotoluene was detected at an estimated concentration of 0.2J ug/L but did not exceed the screening level of 0.37 µg/L. • pH was 6.28 S.U. in Spring 2022 and 7.01 S.U. in Fall 2022.
10	RVAAP-05 Winklepeck Burning Grounds	WBGmw-021	Upper Sharon	Continue to monitor for explosives.	• Explosives were not detected in Spring or Fall 2022. • pH was 6.73 S.U. in Spring 2022 and 7.29 S.U. in Fall 2022.
11	RVAAP-08 Load Line 1	LL1mw-063	Unconsolidated	Continue to monitor for explosives.	• HMX and 2-amino-4,6-DNT were the only explosives detected. 2-Amino-4,6-DNT was detected in Fall 2022 at 0.29 µg/L. HMX was detected at 2.4 µg/L in the Spring 2022 and 1.3 µg/L in the Fall 2022. No detection exceeded screening criteria.
12	RVAAP-08 Load Line 1 (east of Load Line 1 fence)	LL1mw-064	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring or Fall 2022. • pH was 7.71 S.U. in Spring 2022 and 7.7 in Fall 2022.
13	RVAAP-08 Load Line 1	LL1mw-080	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• The explosives TNT, 2-amino-4,6-DNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, HMX, MNX, and RDX were detected; however, only 4-amino-2,6-DNT and RDX exceeded screening criteria. RDX exceeded the RSL of 0.00097 mg/L at a concentration of 0.026 mg/L and 4-amino-2,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.0049 mg/L. • Nitrite and sulfide were not detected in Spring or Fall 2022. • Nitrate was detected at an estimated concentration of 0.098J mg/L in Spring 2022 and was not detected in Fall 2022. • Sulfate was detected at 35 mg/L in Spring 2022 and 25 mg/L in Fall 2022. • Alkalinity was detected at 100 mg/L in Spring 2022 and 140 mg/L in Fall 2022. • TOC was detected at 1.2 mg/L in Spring 2022 and an estimated concentration of 0.96J mg/L in Fall 2022. • pH was 6.61 S.U. in Spring 2022 and 6.41 S.U. in Fall 2022.
14	RVAAP-08 Load Line 1	LL1mw-081	Upper Sharon	Continue to monitor for explosives.	• RDX was the only explosive detected RDX exceeded the RSL of 0.00097 mg/L at an estimated concentration of 0.001 mg/L in Spring 2022. • pH was 5.99 S.U. in Spring 2022 and 6.68 S.U. in Fall 2022.
15	RVAAP-08 Load Line 1	LL1mw-082	Upper Sharon	Monitor for explosives to support the FS.	• TNT, 2-amino-4,6-DNT, 3,5-dinitroaniline, and 4-amino-2,6-DNT were the only explosives detected. These explosives were detected in Spring 2022. No concentration exceeded screening criteria. • pH was 6.15 S.U. in Spring 2022 and 6.67 S.U. in Fall 2022.

Table 8-2. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum (Continued)

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
16	RVAAP-08 Load Line 1	LL1mw-083	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• The explosives TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT were detected at concentrations above screening criteria. TNT exceeded the RSL of 0.00098 mg/L at a concentration of 0.0019 mg/L in Spring 2022 and 0.0024 mg/L in Fall 2022. 2,4-DNT exceeded the RSL of 0.00024 mg/L at a concentration of 0.0025 mg/L in Spring 2022 and 0.0029 in Fall 2022. 2,6-DNT exceeded the residential cleanup goal of 0.000122 mg/L at a concentration of 0.001 mg/L in Spring 2022 and 0.0017 mg/L in Fall 2022. 2 Amino-4,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.0085 mg/L in Spring 2022 and 0.0096 mg/L in Fall 2022. 4-Amino-2,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.016 mg/L in Spring 2022 and 0.014 mg/L in Fall 2022. All other explosives were detected at concentrations below screening criteria. • Alkalinity, nitrite, and sulfide were not detected. • Nitrate was detected at an estimated concentration of 0.25J mg/L in Spring 2022 and 0.15J mg/L in Fall 2022. • Sulfate was detected at 120 mg/L in Spring 2022 and 130 mg/L in Fall 2022. • TOC was detected at 1.2 mg/L in Spring 2022 and an estimated concentration of 0.57J mg/L in Fall 2022. • pH was 4.17 S.U. in Spring 2022 and 4.41 S.U. in Fall 2022.
17	RVAAP-08 Load Line 1	LL1mw-084	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• The explosives TNT, 2,4-DNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT were detected at concentrations above screening criteria. TNT exceeded the RSL of 0.00098 mg/L in the primary and duplicate samples at concentrations of 0.0027 and 0.0029 mg/L in Spring and 0.0025 and 0.0029 mg/L in Fall, respectively. 2,4-DNT exceeded the RSL of 0.00024 mg/L in primary and duplicate samples at concentrations of 0.0016 and 0.002 mg/L in Fall 2022. 2-Amino-4,6-DNT exceeded the RSL of 0.0039 mg/L in the primary and duplicate samples at concentrations of 0.0077 and 0.0078 mg/L in Spring and 0.0061 and 0.0073 mg/L in Fall, respectively. 4-Amino-2,6-DNT exceeded the RSL of 0.0039 mg/L in the primary and field duplicate samples at concentrations of 0.023 and 0.024 mg/L in Spring and 0.015 and 0.018 mg/L in Fall, respectively. All other explosives were detected at concentrations below screening criteria. • Nitrite and sulfide were not detected in the primary or duplicate sample in Spring or Fall 2022. • Nitrate was detected at 0.59 and 0.61 mg/L in the primary and duplicate samples, respectively, in Spring 2022. Nitrate was detected at estimated concentrations of 0.35J and 0.36J mg/L in the primary and duplicate samples, respectively, in Fall 2022. • Sulfate was detected at 110 mg/L in the primary and duplicate samples in Spring 2022 and 120 mg/L in the primary and duplicate samples in Fall 2022. • Alkalinity was detected at 63 and 69 mg/L in the primary and duplicate samples, respectively, in Spring 2022. Alkalinity was detected at 34 and 37 mg/L in the primary and duplicate samples, respectively, in Fall 2022. • TOC was detected at 1.8 mg/L in Spring 2022. TOC was detected at 1.1 mg/L in the primary sample and an estimated concentration of 0.94J mg/L in the duplicate sample in Fall 2022. • pH was 5.58 S.U. in Spring 2022 and 5.69 S.U. in Fall 2022.
18	RVAAP-08 Load Line 1	LL1mw-086	Unconsolidated	Monitor for explosives in this exit pathway well. Although no historical exceedances of screening levels have been detected, ongoing sampling for explosives is recommended in support of the FS.	• The explosives 1,3,5-TNB, TNT, 2-amino-4,6-DNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, and RDX were detected; however, only TNT and RDX exceeded screening criteria. TNT exceeded the RSL of 0.00098 mg/L at a concentration of 0.0013 mg/L in Spring 2022. RDX exceeded the RSL of 0.00097 mg/L at a concentration of 0.0011 mg/L in Spring 2022. No explosives were detected in Fall 2022. • pH was 7.15 S.U. in Spring 2022 and 7.54 in Fall 2022.
19	RVAAP-08 Load Line 1 (southeast of Load Line 1 fence)	LL1mw-087	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in the primary or duplicate samples in Spring or Fall 2022. • pH was 6.68 S.U. in Spring 2022 and 6.78 S.U. in Fall 2022.
20	RVAAP-08 Load Line 1 (southeast of Load Line 1 fence)	LL1mw-089	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring or Fall 2022. • pH was 4.55 S.U. in Spring 2022 and 5.1 S.U. in Fall 2022.

Table 8-3. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum (Continued)

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
21	RVAAP-09 Load Line 2 South	LL2mw-059	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• 1,3,5-TNB, 2,4-DNT, 2-amino-4.6-DNT, 3,5-dinitroaniline, and 4-amino-2,6-DNT were the only explosives detected; however, no concentrations exceeded screening criteria in Spring 2022. 2,4-DNT exceeded the RSL of 0.00024 mg/L at a concentration of 0.00035 mg/L in Fall 2022. • Nitrite and sulfide were not detected in Spring or Fall 2022. • Nitrate was detected at 0.81 mg/L in Spring 2022 and 0.027J mg/L in Fall 2022. • Sulfate was detected at 320 mg/L in Spring 2022 and 19 mg/L in Fall 2022. • Alkalinity was detected at 160 mg/L in Spring 2022 and 110 mg/L in Fall 2022. • TOC was detected at 2.9 mg/L in Spring 2022 and 0.94J mg/L in Fall 2022. • pH was 6.42 S.U. in Spring 2022 and 6.11 S.U. in Fall 2022.
22	RVAAP-10 Load Line 3	LL3mw-237	Upper Sharon	Continue to monitor for explosives.	• The explosives 1,3,5-TNB, TNT, 2-amino-4,6-DNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, HMX, and RDX were detected; however, only TNT, 2-amino-4,6-DNT, 4-amino-2,6-DNT, and RDX exceeded screening criteria in Spring 2022. TNT exceeded the RSL of 0.00098 mg/L at an estimated concentration of 0.042J mg/L. 2-Amino-4,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.0069. 4-Amino-2,6-DNT exceeded the RSL of 0.0039 mg/L at an estimated concentration of 0.027. RDX exceeded screening criteria. RDX exceeded the RSL of 0.00097 mg/L at a concentration of 0.0067 mg/L. • The explosive 2-amino-4,6-DNT was detected at an estimated concentration of 0.00035 mg/L in Fall 2022 but did not exceed the RSL. • pH was 7.02 S.U. in Spring 2022 and 6.27 S.U. in Fall 2022.
23	RVAAP-10 Load Line 3	LL3mw-238	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• Explosives were not detected in Spring 2022. • The explosives 1,3,5-TNB, TNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, HMX, and RDX were detected in Fall 2022. However, only TNT, 4-amino-2,6-DNT, and RDX exceeded screening limits. TNT exceeded the RSL of 0.00098 mg/L at an estimated concentration of 0.028J mg/L, 4-Amino-2,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.028 mg/L, and RDX exceeded the RSL of 0.00097 mg/L at a concentration of 0.0034 mg/L. • Nitrite and sulfide were not detected in Spring or Fall 2022. • Nitrate was detected 0.51 mg/L in Spring 2022 and an estimated concentration of 0.43J mg/L in Fall 2022. • Sulfate was detected at 60 mg/L in Spring 2022 and 53 mg/L in Fall 2022. • Alkalinity was detected at 160 mg/L in Spring 2022 and 140 mg/L in Fall 2022. • TOC was detected at 2.9 mg/L in Spring 2022 and 1.8 mg/L in Fall 2022. • pH was 6.10 S.U. in Spring 2022 and 6.73 in Fall 2022.
24	RVAAP-10 Load Line 3	LL3mw-239	Upper Sharon	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• Explosives were not detected in Spring 2022 • The explosives TNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, and 2-amino-2,6-DNT were detected in Fall 2022. However, none of these explosives exceeded screening limits. • Nitrite and sulfide were not detected in Spring or Fall 2022. • Nitrate was detected at 0.65 mg/L in Spring 2022 and an estimated concentration of 0.43J mg/L in Fall 2022. • Sulfate was detected at 39 mg/L in Spring 2022 and 38 mg/L in Fall 2022. • Alkalinity was detected at 59 mg/L in Spring 2022 and 60 mg/L in Fall 2022. • TOC was detected at 1 mg/L in Spring 2022 and 0.59 mg/L in Fall 2022.
25	RVAAP-10 Load Line 3	LL3mw-241	Upper Sharon	Continue to monitor for explosives.	• Explosives were not detected in Spring 2022. • The explosives 1,3,5-TNB, TNT, 3,5-dinitroaniline, 4-amino-2,6-DNT, 2-amino-4,6-DNT, and RDX were detected in Fall 2022. However, none of these explosives exceeded the screening limits. • pH was 5.76 S.U. in Spring 2022 and 6.19 in Fall 2022.
26	RVAAP-10 Load Line 3	LL3mw-245	Upper Sharon	Monitor for explosives to support the FS.	• Explosives were not detected in Spring or Fall 2022. • pH was 7.02 S.U. in Spring 2022 and 6.19 S.U. in Fall 2022.

Table 8-4. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum (Continued)

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
27	RVAAP-12 Load Line 12	LL12mw-185	Unconsolidated	Continue to monitor for nitrate and ammonia.	• Nitrate was detected at 71 and 74 mg/L in Spring 2022 and 61 and 62 mg/L in Fall 2022 in the primary and duplicate samples, exceeding the MCL of 10 mg/L. • Ammonia was not detected in the primary sample; however, it was detected at an estimated concentration of 0.039 mg/L in the duplicate sample in Spring 2022. Ammonia was detected in the primary and duplicate samples at concentrations of 0.16 and 0.21 mg/L, respectively, in Fall 2022. • pH was 6.61 S.U. in Spring 2022 and 6.68 S.U. in Fall 2022.
28	RVAAP-12 Load Line 12	LL12mw-187	Unconsolidated	Continue to monitor for nitrate and ammonia.	• Nitrate was not detected in Spring 2022. Nitrate was detected at 1,600 mg/L in Fall 2022, exceeding the MCL of 10 mg/L and the RSL of 3.2 mg/L. • Ammonia has no screening level but was detected at 660 mg/L in Spring 2022 and 640 mg/L in Fall 2022. • pH was 6.20 S.U. in Spring 2022 and 6.37 S.U. in Fall 2022.
29	RVAAP-12 Load Line 12	LL12mw-244	Unconsolidated	Monitor for nitrate and ammonia to support the FS.	• Nitrate was not detected in 2022. • Ammonia has no screening level but was detected at 0.026 mg/L in Spring 2022 and 0.61 in Fall 2022. • pH was 7.38 S.U. in Spring 2022 and 7.15 in Fall 2022.
30	RVAAP-12 Load Line 12	LL12mw-245	Unconsolidated	Monitor for nitrate and ammonia to support the FS.	• Nitrate was not detected in 2022. • Ammonia has no screening level but was detected at an estimated concentration of 0.049J mg/L in Spring 2022 and 0.18 mg/L in Fall 2022. • pH was 6.93 S.U. in Spring 2022 and 6.88 S.U. in Fall 2022.
31	RVAAP-12 Load Line 12	LL12mw-246	Unconsolidated	Monitor for nitrate and ammonia to support the FS.	• Nitrate was not detected in 2022. • Ammonia has no screening level but was detected at 0.15 mg/L in Spring 2022 and 0.11 mg/L in Fall 2022. • pH was 6.80 S.U. in Spring 2022 and 7.08 S.U. in Fall 2022.
32	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-173	Homewood	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• 2-Nitrotoluene was the only explosive detected. 2-Nitrotoluene was detected at an estimated concentration of 0.00049J mg/L in Fall 2022 and exceeding the RA of 0.00037 mg/L. • Nitrate, nitrite, and sulfide were not detected in Spring or Fall 2022. • Sulfate was detected at 36 mg/L in the parent sample and 35 mg/L in the duplicate sample in Spring 2022 and 33 mg/L in the primary and duplicate samples in Fall 2022. • Alkalinity was detected at 22 mg/L in the parent sample and 23 mg/L in the duplicate sample in Spring 2022 and 34 mg/L in the primary and duplicate samples in Fall 2022. • TOC was detected at an estimated concentration of 0.86J mg/L in Spring 2022 and 0.44J mg/L in Fall 2022. • pH was 5.02 S.U.
33	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-174	Homewood	Continue to monitor for explosives and assess effectiveness of MNA (anions, TOC, alkalinity, pH, and expanded explosives, which include explosive daughter products) as a remedial option.	• The explosives TNT, 2,4-DNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT were detected at concentrations above screening criteria in Spring 2022. TNT exceeded the RSL of 0.00098 mg/L at a concentration of 0.0056 mg/L. 2,4-DNT exceeded the RSL of 0.00024 mg/L at a concentration of 0.00037 mg/L. 2-Amino-4,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.0087 mg/L. 4-Amino-2,6-DNT exceeded the RSL of 0.0039 mg/L at a concentration of 0.017 mg/L. All other concentrations were below screening criteria. • Sulfide was not detected. • Nitrate was detected at 0.94 mg/L in Spring 2022. • Nitrite was detected at an estimated concentration of 0.007J mg/L in Spring 2022. • Sulfate was detected at 55 mg/L in Spring 2022. • Alkalinity was detected at 10 mg/L in Spring 2022. • TOC was detected at 1.7 mg/L in Spring 2022. • pH was 4.88 S.U. in Spring 2022 and 5.62 S.U. in Fall 2022.
34	RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	FBQmw-175	Homewood	Continue to monitor for explosives.	• Explosives were not detected. • pH was 5.68 S.U. in Spring 2022 and 5.59 S.U. in Fall 2022.
35	RVAAP-43 Load Line 10	LL10mw-003	Homewood	Continue to monitor for carbon tetrachloride to verify recent reduced concentrations.	• Carbon tetrachloride was detected at 4 µg/L in Spring 2022 and 2.9 µg/L in Fall 2022, below the MCL of 5 µg/L. • pH was 6.64 S.U. in Fall 2022

Table 8-5. Summary of 2022 FWGWMP Wells, Rationale, and Results Recommended in 2022 Addendum (Continued)

No	RVAAP-66 Area	Well Name	Aquifer	2022 FWGWMP Sampling Recommendations	2022 Sampling Results
36	RVAAP-66 Facility-wide Groundwater (southern portion of Administration Area)	FWGmw-004	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in the primary or duplicate sample. • pH was 6.83 S.U.
37	RVAAP-66 Facility-wide Groundwater (southwestern portion of facility, south of NACA Test Area)	FWGmw-007	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring 2022 or Fall 2022. • pH was 7.25 S.U. in Spring 2022 and 7.12 S.U. in Fall 2022.
38	RVAAP-66 Facility-wide Groundwater (in DLA Main Ore Storage Area)	FWGmw-010	Unconsolidated	Monitor for explosives to support the FS.	• No explosives were detected except for 3-nitrotoluene in Spring 2022, which was below screening criteria. No explosives were detected in Fall 2022. • pH was 4.50 S.U. in Spring 2022 and 5.08 S.U. in Fall 2022.
39	RVAAP-66 Facility-wide Groundwater (near East Classification Yard)	FWGmw-011	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring 2022 or Fall 2022. • pH was 7.13 S.U. in Spring 2022 and l7.26 S.U. in Fall 2022.
40	RVAAP-66 Facility-wide Groundwater (near East Classification Yard)	FWGmw-012	Upper Sharon	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring 2022 or Fall 2022. • pH was 5.22 S.U. in Spring 2022 and 6 S.U. in Fall 2022.
41	RVAAP-66 Facility-wide Groundwater (southeast of Administration Area)	FWGmw-015	Unconsolidated	Continue to monitor for explosives in this exit pathway well.	• No explosives were detected in Spring 2022 except for 3-nitrotoluene, which was below screening criteria. No explosives were detected in Fall 2022. • pH was 6.71 S.U. in Spring 2022 and 6.79 S.U. in Fall 2022.
42	RVAAP-66 Facility-wide Groundwater (southeast of Administration Area)	FWGmw-016	Upper Sharon	Continue to monitor for explosives in this exit pathway well.	• No explosives were detected in Spring 2022 except for 3-nitrotoluene, which was below screening criteria. No explosives were detected in Fall 2022. • pH was 6.65 S.U. in Spring 2022 and 7.01 S.U. in Fall 2022.
43	RVAAP-66 Facility-wide Groundwater (off-facility, south of State Route 5, south of Load Line 12)	FWGmw-018	Basal Sharon	Continue to monitor for nitrates to support the FS. Discontinue sampling for VOCs, as VOCs have not been detected in well since 2018.	• Nitrate was not detected in Spring 2022 or Fall 2022. • pH was 6.76 S.U. in Spring 2022 and 7.44 S.U. in Fall 2022.
44	RVAAP-66 Facility-wide Groundwater (off-facility, south of State Route 5, south of Load Line 12)	FWGmw-020	Upper Sharon	Continue to monitor for nitrates to support the FS. Discontinue sampling for VOCs, as VOCs have not been detected in well since 2018.	• Nitrate was detected in Spring 2022 at an estimated concentration of 0.011J mg/L. Nitrate was not detected in Fall 2022. • pH was 6.79 S.U. in Spring 2022 and 7.2 S.U. in Fall 2022.
45	RVAAP-66 Facility-wide Groundwater (off-facility, south of State Route 5, south of Load Line 3)	FWGmw-021	Upper Sharon	Continue to monitor for explosives in this exit pathway well.	• No explosives were detected except for 2-nitrotoluene in Spring and Fall 2022 and 3-nitrotoluene in Spring 2022. Concentrations were below screening criteria • pH was 5.86 S.U. in Spring 2022 and 6.32 S.U. in Fall 2022.
46	RVAAP-66 Facility-wide Groundwater (downgradient from Fuze and Booster Quarry Landfill/Ponds)	FWGmw-023	Upper Sharon	Monitor for explosives to support the FS.	• Explosives were not detected in Spring or Fall 2022. • pH was 6.94 S.U. in Spring 2022 and 7.28 S.U. in Fall 2022.
47	RVAAP-66 Facility-wide Groundwater (off-facility, south of State Route 5, south of Load Line 2)	FWGmw-024	Upper Sharon	Continue to monitor for explosives in this exit pathway well.	• No explosives were detected except for 3-nitrotoluene in Spring 2022, which was below screening criteria. No explosions were detected in Fall 2022. • pH was 6.78 S.U. in Spring 2022 and 7.42 in Fall 2022.
48	RVAAP-66 Facility-wide Groundwater (southeastern portion of facility)	SCFmw-004	Basal Sharon	Continue to monitor for explosives in this exit pathway well.	• Explosives were not detected in Spring 2022 or Fall 2022. • pH was 7.63 S.U. in Spring 2022 and 7 S.U. in Fall 2022.

This table does not include a discussion of essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium).

DFFO = Director's Final Findings and Orders
DNT = Dinitrotoluene
FS = Feasibility Study
FWGWMP = Facility-wide Groundwater Monitoring Plan
HMX = Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
MNA = Monitored Natural Attenuation
MNX = Hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-Triazine
NACA = National Advisory Committee on Aeronautics
PAH = Polycyclic Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
RDX = Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RSL = Regional Screening Level
RVAAP = Ravenna Army Ammunition Plant
S.U. = Standard Unit
SVOC = Semivolatile Organic Compound
TNB = Trinitrobenzene
TNT = 2,4,6-Trinitrotoluene
TOC = Total Organic Carbon
VOC = Volatile Organic Compound
µg/L = Micrograms per Liter

9.0 REFERENCES

Bear, J. 1972. *Dynamics of Fluids in Porous Media*. Dover Publications. ISBN 0-486-65675-6.

EQM (Environmental Quality Management, Inc.) 2012. *Facility-Wide Groundwater Monitoring Program RVAAP-66 Facility-Wide Groundwater Monitoring Well Installation Report*. December.

Kammer, H.W. 1982. *A Hydrologic Study of the Ravenna Arsenal, Eastern Portage and Western Trumbull Counties, Ohio*. Master Thesis, Kent State University.

Leidos 2019. *Background Study for Metals for RVAAP-66 Facility-wide Groundwater*. August.

Leidos 2022a. *Facility-wide Groundwater Program Plan, RVAAP-66 Facility-wide Groundwater Addendum for 2022*. April.

Leidos 2022b. *Remedial Investigation Report for RVAAP-66 Facility-wide Groundwater.* February.

Leidos 2023. *Facility-wide Groundwater Monitoring Program Plan RVAAP-66 Facility-wide Groundwater Addendum for 2023.* May.

OHARNG (Ohio Army National Guard) 2014. *Integrated Natural Resources Management Plan at the Camp Ravenna Joint Military Training Center*. December.

Ohio EPA (Ohio Environmental Protection Agency) 2004. *Director's Final Findings and Orders for the Ravenna Army Ammunition Plant*. June.

Portage Environmental 2004. *Facility-Wide Groundwater Monitoring Program Plan for the Ravenna Army Ammunition Plant, Ravenna, Ohio*. September.

SAIC (Science Applications International Corporation) 2010. *Facility-wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant*. March.

SAIC 2011. *Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant*. February.

TEC-Weston 2016. *Remedial Investigation Work Plan for Groundwater and Environmental Investigation Services for RVAAP-66 Facility-Wide Groundwater*. December.

TEC-Weston 2018. *Facility-wide Groundwater Monitoring Program RVAAP-66 Facility-wide Groundwater Annual Report for 2017*. July.

USATHAMA (U.S. Army Toxic and Hazardous Materials Agency) 1978. *Installation Assessment of Ravenna Army Ammunition Plant, Records Evaluation Report No. 132*. November.

Winslow, J.D. and G.W. White 1966. *Geology and Groundwater Resources of Portage County, Ohio*. Geological Survey Professional Paper 511.

THIS PAGE INTENTIONALLY LEFT BLANK.