Health Consultation

Evaluation of Potential for Chemicals Released to Groundwater or Surface Water to Affect Drinking Water in the Nearby Community

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

EPA FACILITY ID: VA1210020730

JANUARY 28, 2015

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

Eastern Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Summary

Introduction

The Agency for Toxic Substances and Disease Registry's (ATSDR) goal is to ensure that the people living near the Radford Army Ammunition Plant (RFAAP) in southwestern Virginia have the best information possible to safeguard their health.

RFAAP has manufactured explosives and propellants for the U.S. military and other uses since the 1940s. In February 2012, a local community group asked ATSDR to evaluate whether contaminants from RFAAP could affect the health of people living near the facility. ATSDR agreed to evaluate effects of groundwater and surface water releases from the site.

This health consultation will evaluate whether operations at RFAAP released contaminants into groundwater or surface water that could reach drinking water sources.

Conclusions

ATSDR reached two important conclusions in the health consultation:

Conclusion 1

Public water systems in the area are not affected by releases from RFAAP. Therefore, contaminants from RFAAP in drinking water from public water systems cannot harm people's health.

Basis for Conclusion

- Public water authorities in the area obtain drinking water from the New River or Claytor Lake, upstream of RFAAP processing areas and wastewater outfalls. Contaminants cannot physically flow upstream, so there is no way for them to enter these systems. Drinking water quality in local public water systems meets regulatory requirements for safe drinking water.
- Contaminants entering the New River from the facility (in wastewater, stormwater, or groundwater) would be diluted or otherwise attenuated by the large river flow to concentrations below health-based guidelines for drinking water. Thus, a former drinking water intake that operated before 2007 downstream of RFAAP, and any past or current intakes far downstream of RFAAP would not likely be affected by contaminants from the facility.

Conclusion 2

Private wells near RFAAP are unlikely to be affected by releases from the facility. Therefore, contaminants from RFAAP in drinking water from private wells near RFAAP are unlikely to harm people's health.

Basis for Conclusion

- Groundwater at RFAAP does contain areas with high levels of some contaminants. Those contaminated areas have been characterized and are monitored regularly.
- The available data and principles of groundwater flow indicate that all groundwater at the site discharges to the New River. Once there, any contaminants in groundwater would be diluted or otherwise attenuated by the large river flow and could not re-concentrate in groundwater downstream.
- No private wells are located within likely flow paths of the groundwater, and wells in the area do not have high enough pump rates to affect groundwater paths.
- Quality of water in private wells in the area, though not affected by RFAAP, may be affected by contaminants from surface water or other local sources due to the local geology.

Next Steps

- ATSDR does not have site-specific recommendations for well testing since this evaluation showed private wells are unlikely to be affected by RFAAP. However, ATSDR recommends that all private well users monitor the quality of their private water well. Information and recommendations for private well testing can be found at the Virginia Department of Health's Private Well Water Information web page (http://www.vdh.state.va.us/environmentalhealth/onsite/regulations/PrivateWellInfo) and in articles on home water quality available from the Virginia Cooperative Extension Service (http://www.pubs.ext.vt.edu/category/home-water-quality.html).

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Background and Purpose

The Radford Army Ammunition Plant (RFAAP) is an active manufacturer of explosives and propellants for the U.S. military and other uses; operations have been conducted on the facility since the 1940s. Figure 1 shows the general location of the facility. The active portion of the plant covers approximately 4100 acres on and around a horseshoe bend of the New River in the Appalachian mountains of southwestern Virginia, about 4 miles from the city of Radford [1]. The Virginia Department of Environmental Quality (VDEQ) administers RFAAP permits for hazardous waste generation and disposal, process and storm water discharges, air emissions, and solid wastes. Region 3 of the U.S. Environmental Protection Agency (EPA) is the lead agency overseeing cleanup of several historical (pre-1984) units identified as potentially contaminated [2].

The Agency for Toxic Substances and Disease Registry (ATSDR) evaluates and makes recommendations to prevent community exposures to hazardous substances in the environment. In February 2012, a New River Valley area community group asked ATSDR to evaluate whether contaminants from RFAAP could affect the health of people living near the site.

Public Comment

ATSDR released a draft of this health consultation for public comment on April 23, 2014. The draft health consultation was available for public review and comment at the Radford Public Library in Radford, Virginia and at the Montgomery-Floyd Regional Library in Christiansburg, Virginia. The document was also available for viewing or downloading from the ATSDR web site and was provided electronically to residents and other interested parties on ATSDR's electronic mailing list for the site. The public comment period was open from April 23, 2014 through May 23, 2014; additional public comments received through June 2014 were also accepted. Public comments received are included in their entirety, with ATSDR responses, in Appendix E beginning on page 100 of this report.

The public comment period was announced to local media outlets. ATSDR presented and discussed the findings of the draft health consultation with community members at a public meeting held May 1, 2014 at Belview Elementary School in Radford, Virginia. ATSDR also met informally with representatives of local environmental groups to discuss the findings on April 30 and May 1 before the public meeting. Copies of the draft report and a fact sheet summarizing the findings were also provided to the community during the public meeting.

As described in the next section, the focus of this health consultation report is on drinking water; other exposure pathways were not evaluated. Based on our discussions with community members and written comments included in the Appendix of this report, a major concern of the community is the possibility of air exposures, particularly potential exposures from open burning at RFAAP. ATSDR acknowledges the community's concern and recognizes the lack of air sampling results as a data gap in the assessment of community exposures. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider the air-related public comments we received on this drinking water health consultation. ATSDR's findings on the air pathway will be conveyed in a separate report.

Focus of This Health Consultation

ATSDR is aware that the community is concerned about exposures to contaminants in air, water, and soil. However, ATSDR is not evaluating air or soil exposures in this report for the following reasons:

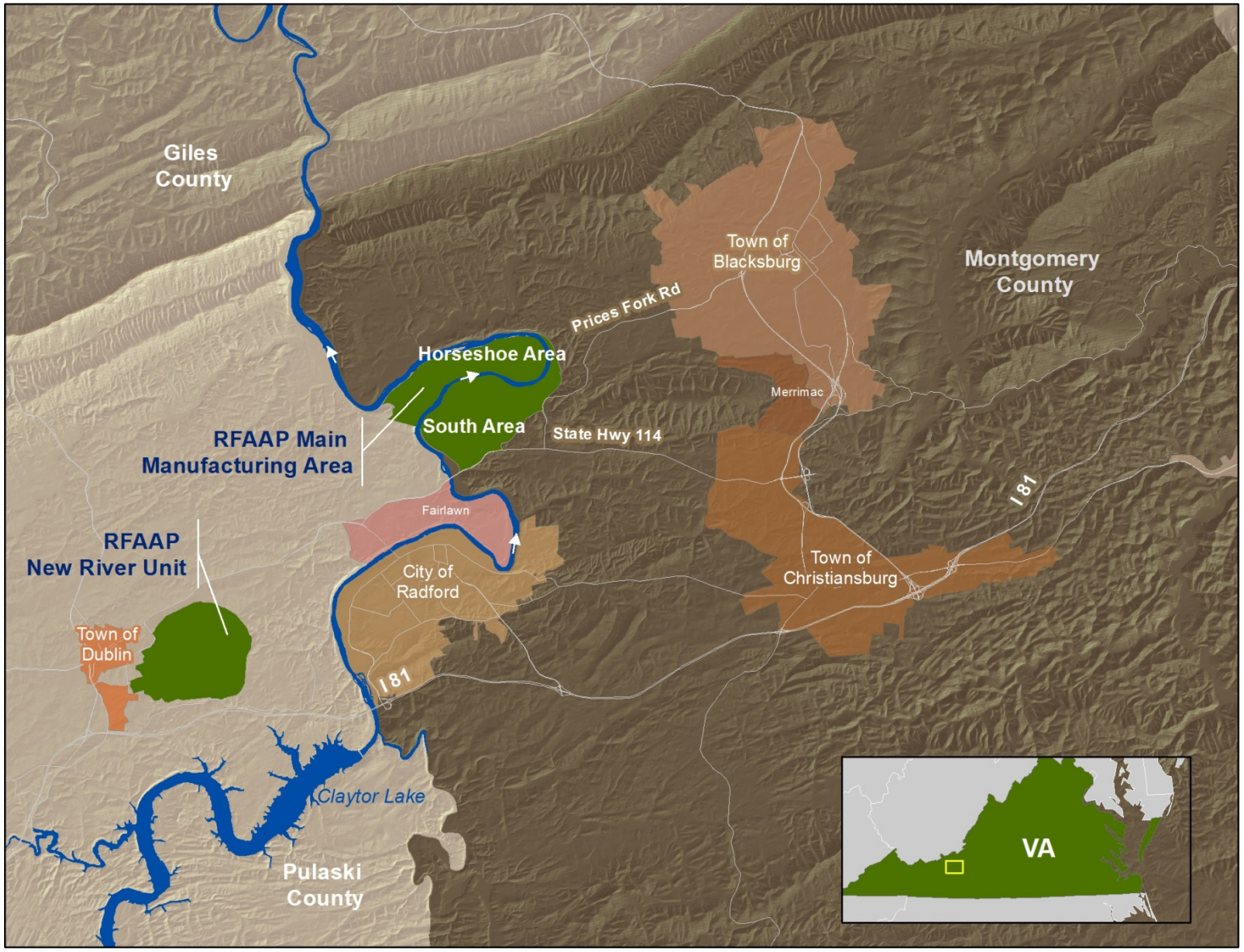
- A lack of monitoring data describing the ambient air concentrations of contaminants released by RFAAP limits ATSDR's ability to perform a meaningful evaluation of the air pathway. The facility's air emissions are subject to permit requirements designed to protect people who might be exposed to emissions downwind from the facility. ATSDR is continuing to explore the air pathway to determine if information or data can be identified to allow evaluation of community exposures to contaminants in air.
- Data do exist on contaminants in soil at RFAAP. However, the public does not have access to the facility and therefore the community is not exposed to contaminants in soil.

ATSDR is focusing on *drinking water* in this report. In particular, we will assess whether the operations at the main Radford Army Ammunition Plant release or released contaminants into *groundwater* or *surface water* that could reach drinking water sources. If contaminants could reach drinking water sources, ATSDR will determine whether the levels of contaminants in drinking water could be high enough to harm people's health.

ATSDR is focusing on RFAAP's Main Manufacturing Area near the city of Radford (see Figure 1). References in this report to RFAAP refer to this area. The inactive New River Unit, located about 6 miles west of the main facility near the town of Dublin, VA, will not be evaluated in detail in this report.[1]

[1] Several investigations at the New River Unit have determined that groundwater was minimally affected by operations there, and groundwater monitoring wells have been abandoned with approval of regulatory agencies [3,4]. Similarly, surface water contamination at the unit was found to be minimal and is being addressed through cleanup activities. This facility was active for only a few years during World War II for bag loading of propellant. Certain areas have been and are used for storage of product from the main RFAAP facility.

Figure 1. General Location of Radford Army Ammunition Plant. Note that river flow is northward, away from the City of Radford.



General Description of Facility and Nearby Areas

As shown in Figure 1, the New River splits the Main Manufacturing Area into two sections, referred to herein as the "South Area" and the "Horseshoe Area." The Horseshoe Area is located within the New River meander in Pulaski County, and the South Area is the remainder of the facility in Montgomery County south and east of the river.[2]

The South Area contains major production units for nitrocellulose production and acid recovery. It also contains a former plant for producing oleum (concentrated sulfuric acid), inactive facilities for producing trinitrotoluene (TNT), and a water treatment plant for supplying process and drinking water. Also in the South Area of the facility are a biological treatment plant for treating organic process wastes, an acid waste treatment plant for neutralizing acid process wastes, a trickling filter plant for treating sanitary waste water, a rolled powder area, and isolated storage buildings for propellant and explosive products.

The Horseshoe Area contains an energetics production area, incinerators for treating propellant wastes, landfills and disposal areas, and isolated storage buildings for propellant and explosive products. The Horseshoe Area is also the location of the open burning ground, where propellant wastes that cannot be treated in the incinerator are burned.

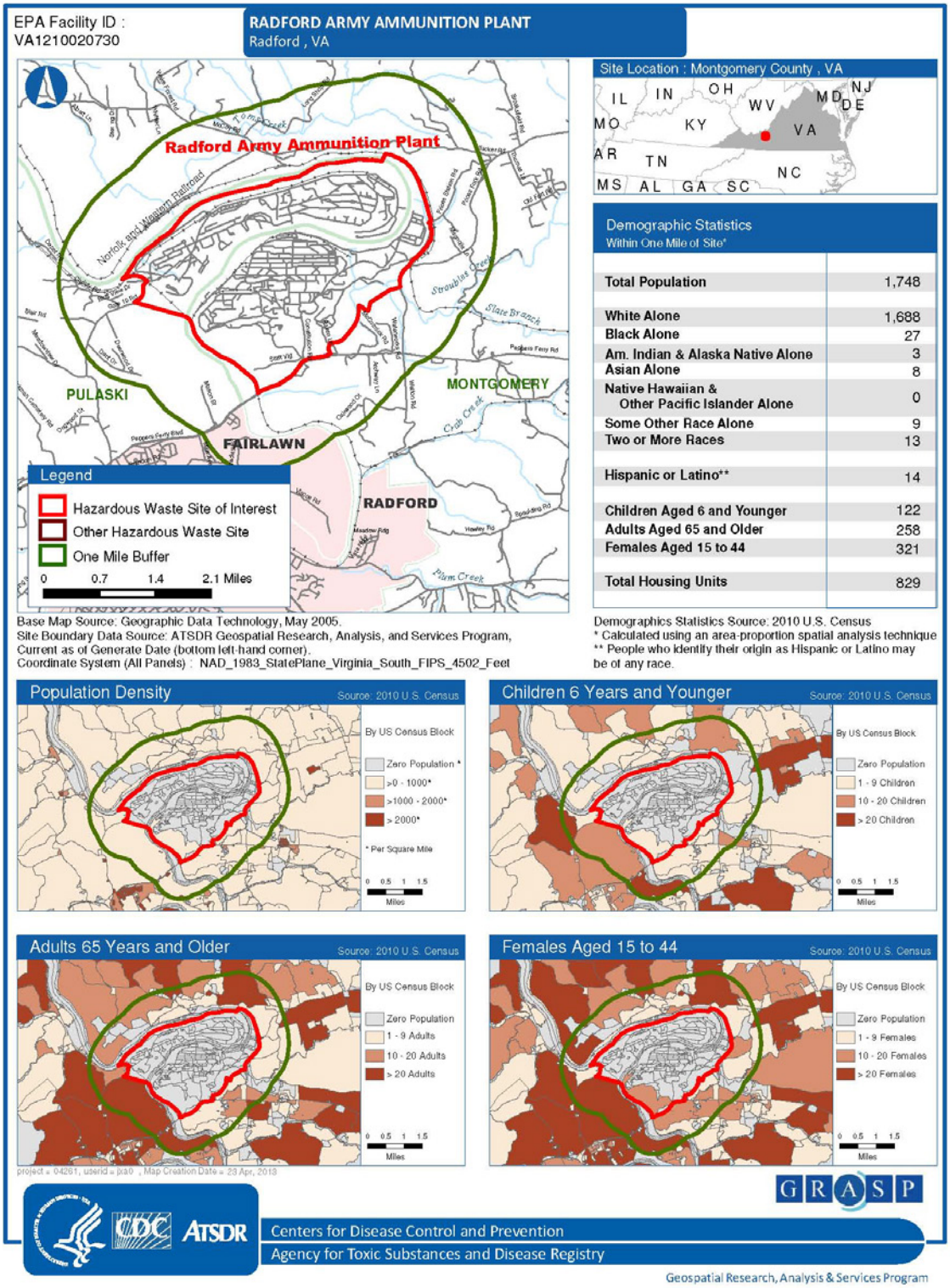
The Installation Restoration Program was established in the 1980s at RFAAP to identify, investigate, and clean up contamination from past production and disposal activities at the facility [1]. Investigations conducted since the 1980s have identified numerous areas formerly used for transport, treatment, or disposal of wastes generated during production. These are named SWMUs (solid waste management units), HWMUs (hazardous waste management units), Areas or Areas of Concern, or by other descriptive names. These sites are in various stages of investigation and cleanup [1,5-7].

The property surrounding RFAAP is mostly rural. Most of the properties bordering RFAAP consist of large undeveloped, agricultural, or residential parcels. Near the main entrance on the southern edge of the facility is an area of more concentrated population. The population within a one-mile radius around the site is described in Figure 2. The total population within a one-mile radius of the site is estimated based on area demographics to be 1,748; of these, 1,688 are white, 27 are black, 3 are American Indian or Alaskan Native, 8 are Asian, 9 are some other race, and 13 are two or more races, Fourteen people identify themselves as Hispanic or Latino. The population contains potentially sensitive groups – 122 children aged 6 or younger, 258 adults aged 65 or older, and 321 women aged 15-44.

RFAAP and the surrounding area include rugged, hilly terrain sloping down or terraced down to the New River. The geology, which can include features of karst terrain, is complex. A more detailed description of local geology and topography, and how they affect groundwater and surface water flow at RFAAP, is presented later in this document beginning on page 31.

[2] Note: Several site reports consider the entire manufacturing facility (Horseshoe Area and South Area) as the Main Manufacturing Area, while others consider the Main Manufacturing Area to only include the South Area. We use the former definition throughout this report.

Figure 2. Demographic Map and Information For a One-Mile Radius Around RFAAP



Pathway Analysis

ATSDR determines whether people may have come into contact with chemicals from a site by examining *exposure pathways*. Exposure pathways consist of five elements which must all be present for exposure to occur:

- A contamination *source*;
- *Transport* of the contaminant through the environment to reach people;
- An *exposure point* where people can come in contact with the contaminant;
- An *exposure route* whereby the contaminant can be taken into the body; and
- An *exposed population* of people actually coming in contact with site contaminants.

We call an exposure pathway *complete* if all five of these pathway elements are clearly evident (either now, in the past, or expected to be in the future). This means exposure to a contaminant has occurred in the past, is now occurring, or will occur in the future. Further evaluation is then required to determine if the exposure was, is, or will be great enough to cause harmful effects in those exposed.

If one or more of the pathway elements is missing, the pathway is *incomplete*, and exposure cannot occur. *Potential* exposure pathways are those for which exposure seems possible, but one or more of the elements is not clearly defined.

ATSDR uses site-specific data or other information about each of the five pathway elements to determine if an exposure pathway is complete. In light of the community's concerns about drinking water and to give the most thorough response to those concerns, ATSDR has opted to present all the data and information available for the five pathway elements in this report. After presenting the available information, we will analyze the pathway and determine whether it is complete.

For the drinking water pathway, any person using water affected by contamination would be the *exposed population*. Swallowing water or breathing contaminants from the water during other household use are the *exposure routes*. The following section describes the *exposure point*, how people receive drinking water in the area. This discussion is followed by a presentation of possible *sources* of contamination from RFAAP: namely, groundwater contaminants and releases to surface water. A presentation of water quality data related to wells and public water supplies in the area is included in this section. Finally, contaminant *transport* through groundwater and surface water will be discussed as it connects source contaminants with the exposure point of nearby residents' drinking water taps.

Exposure Point Element of Drinking Water Pathway

Drinking Water Supplies in the General Area

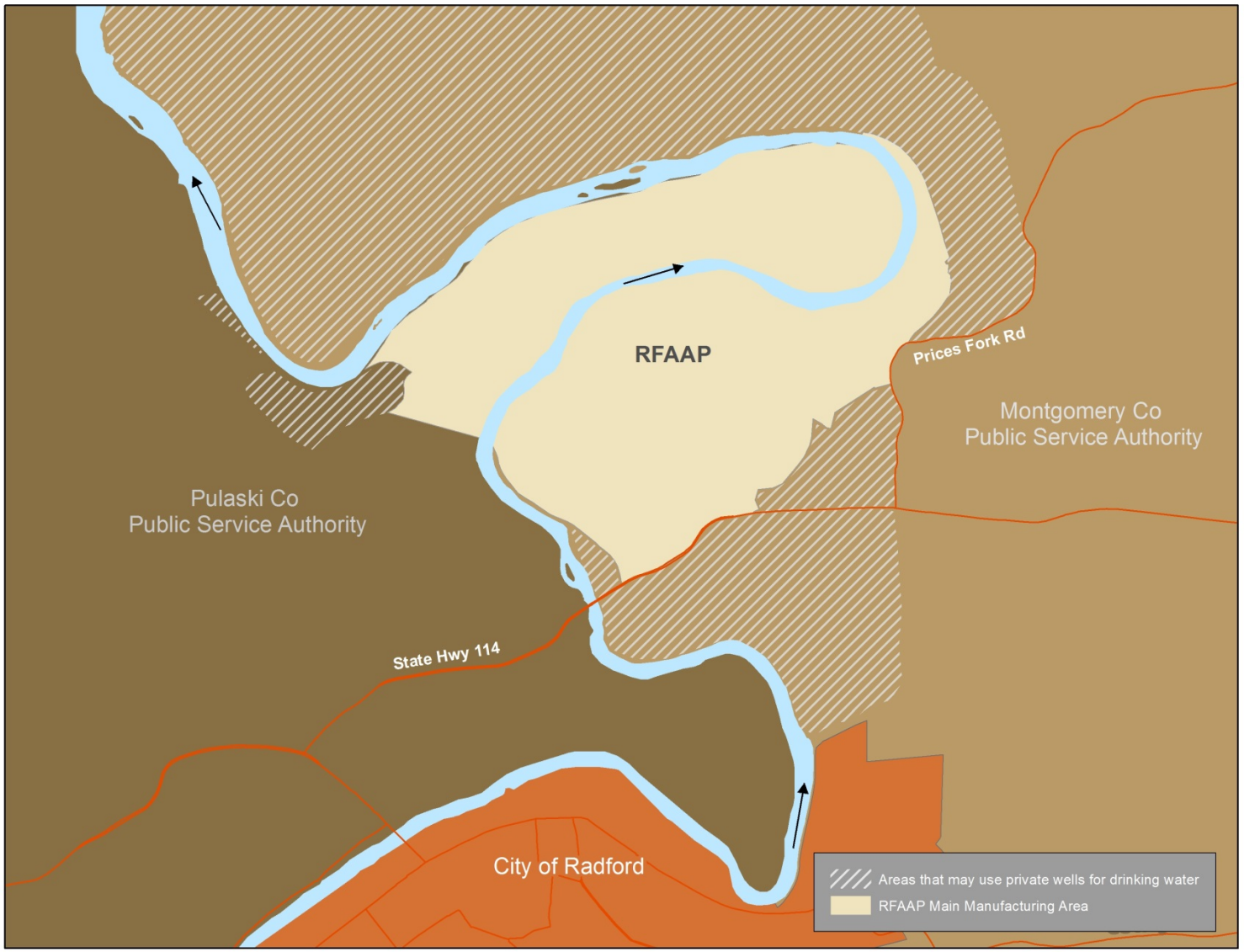
Residents near RFAAP obtain drinking water from either private wells or public water systems that draw water from the New River. Figure 3 shows sources of drinking water in communities near RFAAP. Public water systems near and downstream of RFAAP include:

- City of Radford – Supplies treated water within the city limits of Radford. The source of water for the City of Radford is the New River upstream of Radford and below Claytor Lake [8-10].

- Montgomery County Public Service Authority – supplies water to unincorporated areas of Montgomery County. The Prices Fork/ Merrimac subsystem is the closest to RFAAP located east and northeast of the facility. The Montgomery County Public Service Authority purchases water from RFAAP to supply to this subsystem. The source of this water is the New River on the upstream side of the facility [11,12; personal communication, Bob Fronk, Montgomery County Public Service Authority, February 4, 2013].
- Pulaski County Public Service Authority – Supplies treated water to unincorporated areas of Pulaski County, including some properties west of RFAAP. The source of this water is Claytor Lake, located upstream on the New River above Claytor Dam [13; personal communication, Jared Linkous, Pulaski County, February 14, 2013].
- Giles County Public Service Authority – Supplies treated water to Giles County, several miles downstream of RFAAP. The source for this water is groundwater from 3 wells operated by Giles County [14; personal communication, Steve Newby, Giles County Public Service Authority, July 11, 2013]. The wells are several miles away from the RFAAP boundary.
- Blacksburg/ Christiansburg VPI Water Authority – Supplies treated water to the towns of Blacksburg (including Virginia Tech) and Christiansburg, located several miles east of the facility. The source for this water is the New River upstream of RFAAP and near Peppers Ferry Road. [15,16]

Not all properties are connected to public systems. According to the 2011 New River Valley Water Supply Plan, Montgomery County has 9 private community water systems using groundwater as a drinking water source, and Pulaski County has 7 [17]. Some areas are not served by public or community systems and private wells are used to supply water. Figure 3 shows the general areas not served by the area public systems as cross hatch lines [18, personal communication, Bob Fronk, Montgomery County PSA, February 4, 2013; personal communication, Jared Linkous, Pulaski County, February 14, 2013]. Figure 3 also indicates approximate locations of private wells listed in a database from the early 1990s [18,19]. It is not known if private wells in areas now served by public systems are still in use. Many private wells are likely to have been installed since the 1990s, most likely in the areas not served by public systems.

Figure 3. Sources of Drinking Water in the Area Surrounding RFAAP. Green dots labeled "private wells" were identified from a historical database (from the 1990s) and may not be used today; also, many more wells could exist now. Cross hatched lines indicate areas that are not currently served by public water and therefore probably are on private wells.



Source Element of Drinking Water Pathway

RFAAP Releases Affecting Groundwater

RFAAP operations have resulted in some releases of contaminants to groundwater beneath the site. Spills, leaks, and past operations such as unlined ponds for holding or treating waste water may have resulted in contaminants filtering through the ground into the groundwater beneath the site. The Army, EPA, and VDEQ have conducted multiple investigations and inspections to determine the areas on site most likely to have contamination from past spills or processing and to characterize the contamination. These areas mostly represent past releases, and many of the sites have been cleaned up. Some sites are subject to compliance monitoring of groundwater under VDEQ corrective action permits. The many reports describing the investigation and ongoing monitoring of these areas represent the primary source of groundwater sampling data for this health consultation. ATSDR obtained reports referenced in the following discussion and tables from the Online Information Repository found on the RFAAP Installation Restoration Program website at www.radfordaapirp.org [1] and from staff at RFAAP and VDEQ.

Figure 4 shows general locations of SWMUs, HWMUs, and other areas investigated at RFAAP (modified from site figures available publicly) [1]. The groundwater sampling available is summarized in Table 1. Table 1 groups the units according to their general location in either the South Area or Horseshoe Area, as indicated by table subheadings.

Figure 4. Units at RFAAP

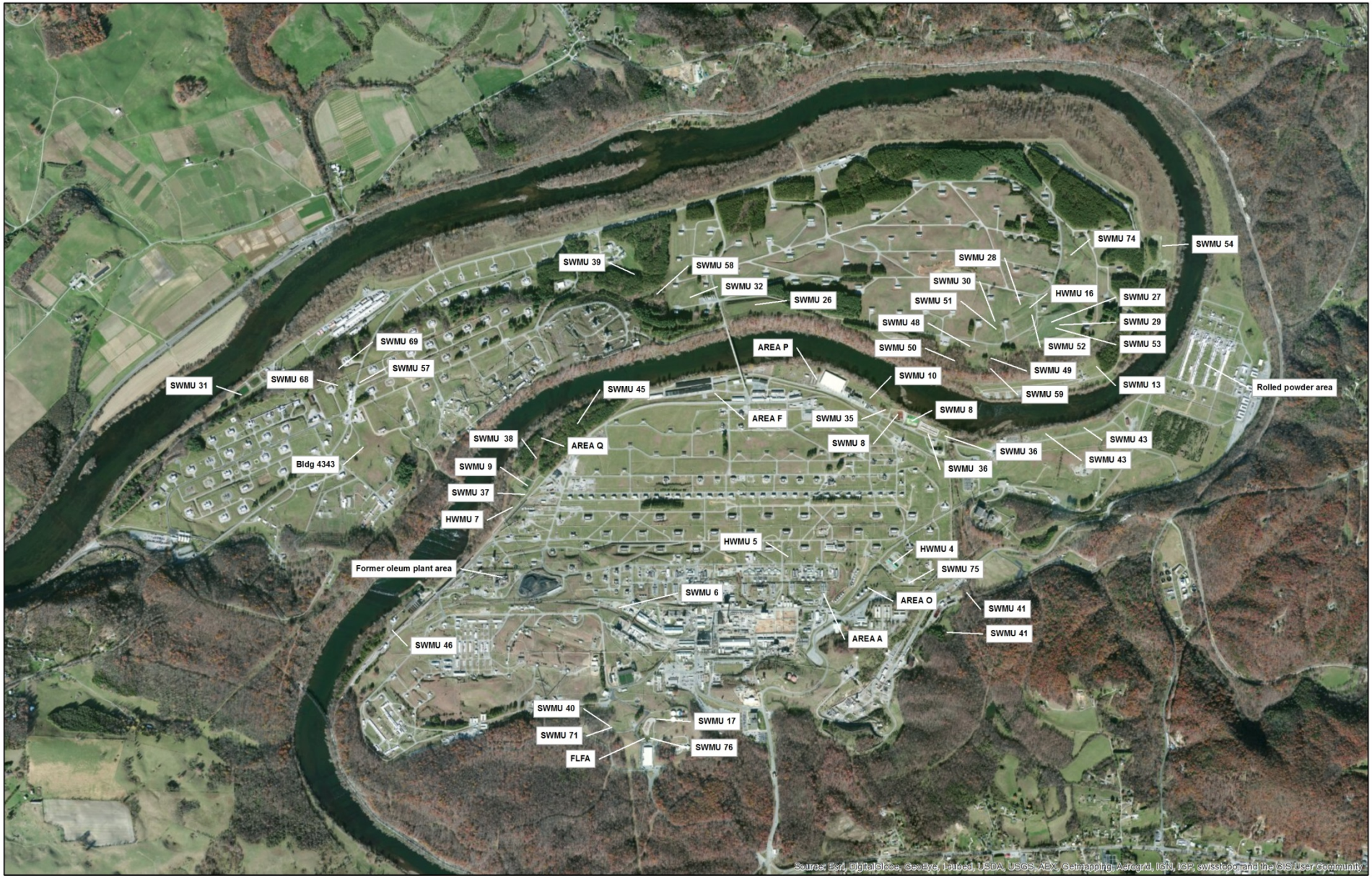


Table 1. Units at Radford Army Ammunition Plant and Groundwater (GW) Data Availability

South Area, Units Along River, From West to East				
Area	**Description**	**GW Sampled?**	**When?**	**Notes For Units Not Sampled**
SWMU 46	Waste Propellant Disposal Area	Yes	2006	
HWMU 7	Former Surface Impoundment	Yes	1985, 2008-2012	
SWMU 37	Calcium Sulfate Drying Bed	Yes	2008	
SWMU 9	C-line nitrocellulose wastewater	Yes	1980	
SWMU 38	Calcium Sulfate Drying Bed	Yes	2008	
Area Q	Abandoned Lagoon Used for Calcium Sulfate Disposal	No	-	GW likely similar to adjoining SWMU 38
SWMU 45	Sanitary Landfill	Yes	1991, 2008	
Area F	Drum/ Container Storage Area	Yes	2006	
Area P	Scrap Metal Salvage Yard	Yes	2007	
SWMU 10	Former Equalization Basin for Biological Treatment Plant	Yes	1990, 1991, 2008-2012	
SWMU 35	Calcium Sulfate Drying Bed	Yes	1991, 1993, 2008	
SWMU 8	AB-Line acidic wastewater	Yes	1980	
SWMU 36	Calcium Sulfate Drying Bed	No	-	Soil samples showed no risk using soil screening for GW protection [20]
SWMU 43	Sanitary Landfill	Yes	1991	

Table 1, continued – Groundwater (GW) Data Availability

South Area, Units Away (>500 ft) From River, Generally From West to East				
Area	**Description**	**GW Sampled?**	**When?**	**Notes For Units Not Sampled**
Oleum Plant	Former Oleum Plant	Yes	2007	
SWMU 6	Acidic Wastewater Lagoon	Yes	1992	
SWMU 40	Sanitary Landfill Nitroglycerine Area	Yes	1995, 2007, 2011-2013	
SWMU 71	Flash Burn Parts Area	No	-	GW likely similar to adjoining SWMU 40
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	Yes	1995, 2007	
SWMU 76	Waste Oil Underground Storage Tanks (2)	No	-	Impacted Soil Removed and Official Closure by VDEQ in 1991 [21]
FLFA	Former Lead Furnace Area	Yes	2007	
HWMU 5	Former Surface Impoundment	Yes	1996-2012	
Area A	Nitrocellulose Line A Rainwater Ditch	No	-	Soil samples showed limited downward migration of contamination; GW considered unlikely to be affected [22]
Area O	Underground Fuel Oil Spill	Yes	1992, 1993, 2008	
HWMU 4	Acidic Wastewater Lagoon	Yes	1984	
SWMU 75	Waste Oil Underground Storage Tank	No	-	Impacted Soil Removed and Official Closure by VDEQ in 1995 [22]
SWMU 41	Red Water Ash Landfill	Yes	1992	
Horseshoe Area, Western				
Area	**Description**	**GW Sampled?**	**When?**	**Notes For Units Not Sampled**
SWMU 31	Coal Ash Settling Lagoons	Yes	1998, 2008	
SWMU 68	Former (1958-1978) Chromic Acid Treatment Plant	No	-	Impacted Soils Removed & Soil Samples Passed Soil Screening for GW Protection [22]
SWMU 69	Former Settling Pond by Chromic Acid Treatment Plant	No	-	Impacted Soils Removed & Soil Samples Passed Soil Screening for GW Protection [22]
SWMU 57	Former Acid Settling Pond	Yes	2008, 2010	
Building 4343	Former Cadmium Plating Facility	No	-	Soil samples showed vertical migration of contaminants was limited and unlikely to affect GW beneath the site [23]

Table 1, continued – Groundwater (GW) Data Availability

Horseshoe Area, Central				
Area	**Description**	**GW Sampled?**	**When?**	**Notes For Units Not Sampled**
SWMU 39	Incinerator Wastewater Ponds	Yes	1993	
SWMU 58	Rubble Pile	No	-	Soil samples showed limited potential to affect GW beneath the site [24]
SWMU 32	Inert Waste Landfill	Yes	1992	
SWMU 26	Fly Ash Landfill	Yes	1992	
Horseshoe Area, Eastern				
Area	**Description**	**GW Sampled?**	**When?**	**Notes For Units Not Sampled**
SWMU 50	Calcium Sulfate Disposal	Yes	2007	
SWMU 48	Oily Wastewater Disposal	Yes	1996, 2007	
SWMU 59	Bottom Ash Pile	Yes	2007	
SWMU 49	Red Water Ash Disposal	Yes	2007	
SWMU 51	TNT Neutralization Sludge Disposal	Yes	2006, 2007	
SWMU 30	Asbestos Disposal Trench	No	-	GW likely similar to several nearby units
SWMU 28	Sanitary Landfill	Yes	1992, 2008	
HWMU 16	Closed Hazardous Waste Landfill	Yes	1982-1984, 2003-2012	
SWMU 52	Closed Sanitary Landfill	No	-	GW likely similar to several nearby units
SWMU 27	Calcium Sulfate Landfill	Yes	1985, 1991-1993	
SWMU 53	Activated Carbon Disposal	Yes	1985, 1991-1993	
SWMU 29	Fly Ash Landfill #2	Yes	1985, 1991-1993	
SWMU 74	Inert Landfill	Yes	1991	
HWMU/ SWMU 13	Open Burning Ground	Yes	1991, 2003-2012	
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	Yes	1991-1999, 2002-2007, 2011-2012	
NOTE: Individual groundwater sampling references are presented in Table A.1 in Appendix A.				

ATSDR created the summary in Table 1 from examining numerous site documents available in the RFAAP online information repository. ATSDR also obtained additional reports from federal and state partners. While additional groundwater sampling data may exist, the groundwater sampling data reviewed by ATSDR represent the majority of the data that have been collected at RFAAP. These data are sufficient for describing the general state of the groundwater beneath the site.

Due to the large amount of data, ATSDR needs a way to prioritize its evaluation to focus on contaminants most likely to pose a public health concern. The following paragraph describes the screening process ATSDR used for the RFAAP groundwater data. This procedure is typical of how ATSDR evaluates contamination at sites [25].

ATSDR examined the groundwater sampling data we located for RFAAP. Appendix A, Table A.1, indicates the groundwater sampling reviewed for the various units listed in Table 1 and which chemical compounds were analyzed. Only some of the compounds analyzed were actually reported as detected in the results. ATSDR then compared the concentrations of detected contaminants with drinking water *comparison values*. Comparison values, or CVs, are substance-specific concentrations in water which would not be expected to have any harmful health effects, even if a child drank the water every day. See Appendix B for more information about CVs. Concentrations of chemicals in water at levels higher than drinking water CVs do not necessarily result in harmful effects but generally require further evaluation. To further evaluate chemicals that exceed CVs, ATSDR considers site-specific information to better describe actual exposures that may be occurring. If exposures are occurring, ATSDR determines the potential for harmful effect using scientific studies on the toxicological and epidemiological effects of the chemical of interest.

For this health consultation, ATSDR used an exceedance of the CV for drinking water as an indication that groundwater could be a source of contamination for drinking water supplies in the area. Further evaluation will be performed to determine if exposure to groundwater contaminants through drinking water is actually possible.

Appendix A contains tables showing which contaminants were detected in the various sampling events for the different units at RFAAP. Highlighted cells in the tables indicate contaminants detected at least once in groundwater at a level above ATSDR's drinking water CVs, or contaminants for which no CV is available. The CVs used and information on maximum concentrations detected for chemicals detected above the CVs are also presented. The tables in Appendix A are organized as follows:

- Table A.1 – Lists groundwater sampling data available for RFAAP units listed in Table 1.
- Table A.2a – Tabulates detections of metals, inorganics, and explosives-related compounds for each identified study.
- Table A.2b – Shows the maximum concentrations detected for metals, inorganics, and explosives-related compounds that exceeded the corresponding CV. Gives the number of studies with exceedances, CVs, and cancer screening values for each analyte.
- Table A.3a – Tabulates detections of pesticides and volatile compounds for each identified study.
- Table A.3b – Shows the maximum concentrations detected for pesticides and volatile compounds that exceeded the corresponding CV. Gives the number of studies with exceedances, CVs, and cancer screening values for each analyte.

- Table A.4a – Tabulates detections of semi-volatile compounds and dioxins/ furans for each identified study.
- Table A.4b – Shows the maximum concentrations detected for semi-volatile compounds and dioxins/ furans that exceed the corresponding CV. Gives the number of studies with exceedances, CVs, and cancer screening values for each analyte.

Summary of Groundwater Contaminants at RFAAP

Table 2 lists 57 compounds that were detected at least once in RFAAP groundwater at a concentration above the corresponding drinking water CV.

Table 2. List of Compounds Detected in RFAAP Groundwater at Concentrations Above Drinking Water Comparison Values (CVs), or For Which No CV Exists

Fluoride*	2,4-Dinitrotoluene	Benzo(a)anthracene*
Nitrate	o-Nitrotoluene (2-Nitrotoluene)*	Benzo(a)pyrene*
Sulfate	RDX (cyclonite)	Benzo(b)fluroanthene*
Perchlorate	2,4,6-Trinitrotoluene	Benzo(g,h,i)perylene*
Aluminum	alpha-BHC (Benzene hexachloride)*	Bis(2-chloroethyl) ether
Antimony	Chlordane	Bis(2-ethylhexyl) Phthalate
Arsenic	Heptachlor epoxide	Carbazole*
Beryllium	Acetone*	Indeno(1,2,3-cd)pyrene *
Cadmium	Benzene*	n-Nitrosodiphenylamine
Chromium	Bromodichloromethane*	Phenanthrene
Copper	Carbon Tetrachloride	Octachlorodibenzodioxin
Iron	Chloroethane (Ethyl chloride)	Octachlorodibenzofuran*
Lead	1,1-Dichloroethane	Heptachlorodibenzodioxin
Manganese	1,2-Dichloroethane	Heptachlorodibenzofuran
Mercury	Dimethyl ether (methoxymethane)*	Hexachlorodibenzodioxin*
Nickel	Isopropanol (2-Propanol)*	Hexachlorodibenzofuran
Vanadium	Trichloroethylene	Pentachlorodibenzodioxin*
2,6-Dinitrotoluene	2-Methylnaphthalene	Pentachlorodibenzofuran*
Dinitrotoluene mixture	Acenaphthylene	Tetrachlorodibenzofuran
*compounds detected above CV in only 1 study/location.		

Note that the contaminants in groundwater at RFAAP are not widespread throughout the facility; rather, they are associated with specific units or areas studied. Several units had no contaminants detected above CVs, and other units had only a few. In general, the areas of contaminated groundwater associated with specific units have been characterized through the investigations and monitoring required for Corrective Action and RCRA permitting processes.

This evaluation shows that contaminants have been detected in groundwater beneath several units at the RFAAP facility. Some of the concentrations of these contaminants were, and in some cases still are, higher than health-based screening values. Therefore, *the groundwater beneath the particular units where contaminants were detected could be considered a source of contaminants to the drinking water pathway.* Further evaluation is needed to determine if contaminants in groundwater can be transported to a point of exposure and complete the exposure pathway. The transport element is discussed beginning on page 31.

RFAAP Releases to Surface Water

RFAAP is permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program at VDEQ to release treated wastewater from current operations and allow release of stormwater (which may run off from process or contaminated areas) through various outfalls to the New River [26]. The permit sets limits on various constituents of the outfall releases which must be monitored and reported to VDEQ on a regular basis for compliance with the permit [27]. Summaries of these releases are compiled and reported as part of the Toxic Release Inventory (TRI) as well [28]. Discharge monitoring reports submitted to comply with the VPDES permit and TRI data are the primary source of surface water release data ATSDR located for this site [27,28].

In addition to current releases, past RFAAP operations resulted in some releases of contaminants to surface water. Spills, leaks, and past operations such as unlined ponds for holding or treating waste water may have resulted in contaminants running off into surface water on site (in addition to affecting groundwater as discussed previously). Some surface water data were available on contaminant levels in the investigative reports reviewed and summarized previously for groundwater contamination data. In general, the surface water data in these reports are limited in number, isolated to describing releases only at particular units, and do not represent current conditions of surface water at the site because most data were from the 1980s and 1990s. ATSDR did not include these surface water data in its evaluation. The releases described in VPDES discharge monitoring reports are of better quality and sufficient for the purposes of our evaluation.

Figure 5 shows approximate locations of outfalls and intakes in the immediate vicinity of RFAAP. Outfalls from RFAAP enter either the New River or Stroubles Creek, which discharges to the New River. RFAAP's effluent outfalls release treated wastewater, non-contact cooling water, and other process waters. Stormwater outfalls release rainwater or other water that may have flowed over process or contaminated areas.

Tables 3 and 4 list the RFAAP outfalls covered under the VPDES permit and the monitoring required by the permit [26]. For each effluent outfall, an estimate of the daily volume of discharge is given by listing the mean of monthly average flows reported in VPDES discharge monitoring reports from mid-2009 to early 2013 [27]. For stormwater outfalls, the average rain event volume (for monitoring reports from the same dates) is shown. These volumes should be considered very rough estimates to gain an idea of the relative volumes of discharges from the various outfalls at RFAAP.

Although the greatest volume of discharge comes from effluent outfall 006, it releases only cooling water (that never contacts process contaminants) and overflow of uncontaminated water drawn from the New River. Effluent outfalls 007 (treated acidic manufacturing wastewater) and 029 (treated organic-containing wastewater from the biological treatment plant) are the major process waste water streams and are subject to monitoring and limits for the greatest range of chemicals.

Figure 5. Outfalls and Intakes in the RFAAP Area

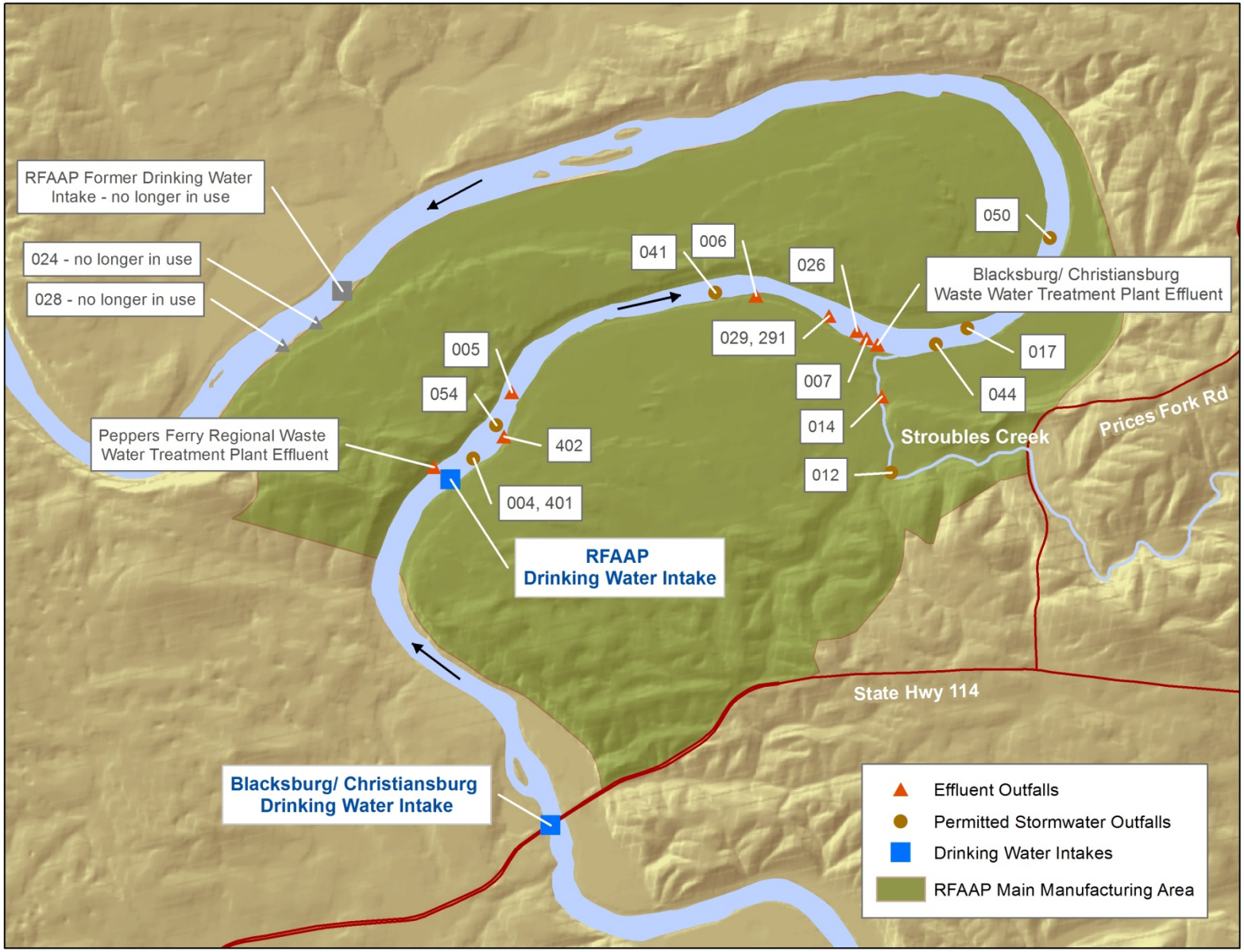


Table 3. Radford Army Ammunition Plant Permitted Effluent Outfalls and Monitoring Requirements

Effluent Outfall #	Description of Flow	Average Flow from 2009-2013 Discharge Monitoring Reports, Million Gallons per Day (MGD)	Current Requirements for Monitoring/ Reporting Under VPDES Permit (Differing Sampling Frequencies Apply)														
			Flow	pH	Sulfate	TSS	Oxidized Nitrogen	Temp	Heat Rejected	BOD5	COD	Acute Whole Effluent Toxicity	TNT Nitrobodies	Ammonia as N	Total Residual Chlorine	Volatile Chemicals	Metals
005	Wastewater from oleum plant (not operating) and noncontact cooling water	0.3	×	×	×	×	×	×	×	×	×						
006	Non-contact cooling water and raw water overflow	9.76	×	×	×		×	×	×	×	×	×					
007	Nitrocellulose and nitric acid manufacturing wastewaters, boiler, blowdown, non-contact cooling water	3.65	×	×	×	×	×	×		×	×	×		×		×	×
014	Contaminated spring water	0.07	×	×	×		×			×	×						
024	Filter backwash (no longer in use)	-	×	×	×	×	×			×	×			×			
026	Trickling filter plant effluent	0.22	×	×	×	×	×			×	×			×	×		
028	Treated sanitary wastewater (no longer in use)	-	×	×	×	×	×			×	×				×		
029	Biological treatment plant effluent	0.87	×	×	×	×	×	×	×	×	×	×				×	×
291	TNT or DNT manufacturing wastewater	0.07	×										×				
402	Non-storm water	0.07	×	×	×		×	×									
999	Mathematical sum of effluent outfalls	-			×	×	×			×	×						
Note: "-" means no flow was reported in any monitoring reports.																	

Table 4. Radford Army Ammunition Plant Permitted Stormwater Outfalls and Monitoring Requirements

Stormwater Outfall #	Source of Storm Water Runoff	Average Flow per Rain Event from 2009-2013 Discharge Monitoring Reports, Million Gallons (MG)	Current Requirements for Monitoring/ Reporting Under VPDES Permit (Differing Sampling Frequencies Apply)								
			Flow	pH	Nitrate/Nitrite	Sulfate	TSS	Oil & Grease	Dissolved Copper	Dissolved Lead	Dissolved Zinc
004	Coal pile, solvent area, adjacent to power house	0.13	×	×	×	×					
012	TNT/DNT manufacturing area	0.006	×	×		×					
017	Open burning ground (rarely discharges even during major rain events)	-	×	×			×		×	×	×
041	Approximately 120 storm water outfalls not listed separately (monitoring rotated among outfalls)	0.07	×				×	×			
044	Ballistics testing area	0.05	×				×	×			
050	Landfills and disposal areas in eastern Horseshoe Area	0.03	×		×		×	×		×	
054	Propellant area and HWMU 7	0.02	×				×				×
401	Treated coal pile runoff	0.08	×	×			×				
Note: "-" means no flow was reported in any monitoring reports.											

To understand how the actual effluent and stormwater releases relate to the permit limits, ATSDR examined discharge monitoring reports and data from June 2009 to January 2013 provided by VDEQ [27]. Appendix B contains tables comparing permit limits and maximum reported values from these dates. The tables in Appendix C are organized as follows:

- Table C.1 – Permit limits and highest reported measurements for monitoring of the effluent outfalls
- Table C.2 – Permit limits and highest reported measurements for specific monitoring of metal and organic compounds in outfalls 007 and 029
- Table C.3 – Permit limits and highest reported measurements for specific monitoring of certain parameters in overall effluent outfall releases (denoted as outfall 999)
- Table C.4 - Permit limits and highest reported measurements for monitoring of the stormwater outfalls

The discharge monitoring reports indicate that effluent releases from RFAAP met permit requirements most of the time. For specific effluent outfalls, Table C.1 indicates that the only parameters ever reported outside of permit limits were pH, biological oxygen demand, and acute whole effluent toxicity:

- Five effluent outfalls (005, 006, 007, 026, and 402) had releases during some months of reporting with pH "excursions" outside of the permitted range of 6 to 9. In some cases, the reason for the excursion could not be identified, but in most cases reports identified spills or equipment malfunction as causing the excursion and detailed actions taken to address the problem.
- Biological oxygen demand (BOD) in outfall 007 exceeded the quantity limit once, in March 2010; the concentration limit was not exceeded. The cause of the exceedance was not identified in reports.
- Acute toxicity in outfall 029 from the biological treatment plant was exceeded twice, in July 2011and in October 2012. In the first instance, process releases of metals or other propellant constituents were thought to be contributing to effluent toxicity, although no exceedances for any constituents had occurred. RFAAP implemented process changes to reduce releases from the process, and effluent toxicity improved afterwards [29]. The October 2012 exceedance was attributed to a temporary decrease in nitroglycerine treatment through the biological treatment plant, possibly a result of production shutdowns; the plant took measures to increase biomass and treatability [30].

As shown in Tables C.2 and C.3, specific compounds monitored in effluent outfalls 007 and 029 and combined effluents (outfall 999) were all well below permit limits, and in most cases below quantitation limits.

Stormwater outfalls have fewer permit limits than effluent outfalls. Table C.4 shows that the only reported value exceeding a permit requirement was total suspended solids in stormwater outfall 401. This parameter was reported once at 62 mg/L, higher than the permit limit of 50 mg/L.

ATSDR notes that even if surface water releases meet permit limits, those releases add to the burden of contaminants in the environment. The effluent water itself would definitely not be acceptable as a drinking water source. The quantitation limits for analysis of the effluent are set only low enough to demonstrate that permit limits are met, not necessarily that the water is safe to drink. Nevertheless, ATSDR will focus the rest of the discussion only on compounds that were detected above quantitation limits. Although some amount of these compounds could be released, there is no way to quantify compounds that were reported as less than the quantitation limit.

In addition to the discharge monitoring reports, the VDEQ provided limited data on releases of polychlorinated biphenyls (PCBs) from outfalls at RFAAP [31]. These data were collected in 2011 to support development of total maximum daily load values for PCBs in the New River. None of the total PCB concentrations exceeded drinking water CVs.

Summary of Surface Water Releases at RFAAP

From the tables in Appendix C, ATSDR identified the chemical parameters that were detected above quantitation limits, and determined the highest detection in any effluent or stormwater outfall. ATSDR converted quantity values to concentrations, if necessary, by dividing the maximum daily quantity released by the average monthly flow volume per day. This was done so that the concentrations released could be compared with drinking water CVs. This comparison is for perspective only – the outfalls are not used for drinking water. Table 5 below summarizes the chemical constituents detected above quantitation limits in outfalls from RFAAP (including the PCB data provided separately).

Table 5. Compounds Detected Above Quantitation Levels in RFAAP Outfalls to New River

Compound	Highest Reported Concentration in Effluent Outfall	Highest Reported Concentration in Stormwater Outfall	Drinking Water Comparison Value
Sulfates	2,490,000 µg/L	3,150,000 µg/L	250,000 µg/L – secondary MCL
Oxidized Nitrogen (as N)	395,000 µg/L	Not measured	10,000 µg/L – MCL for nitrate and nitrite
Nitrate/ Nitrite	Not measured	1,500 µg/L	10,000 µg/L – MCL for nitrate and nitrite
Ammonia as N	4,900 µg/L	Not measured	30,000 µg/L - LTHA
Chromium	338 µg/L*	Not measured	9 – EMEG for hexavalent Cr
Copper	699 µg/L*	No data	100 µg/L – iEMEG
Cyanide	1430 µg/L*	Not measured	6 µg/L – RMEG
Lead	904 µg/L*	0.0016 µg/L	15 µg/L – AL
Nickel	593 µg/L*	Not measured	100 µg/L – LTHA
Zinc	465 µg/L*	11.3 µg/L	2,000 µg/L – LTHA
Total PCBs	0.00926 µg/L	0.00561 µg/L	0.5 µg/L – MCL 0.018 µg/L – CREG†

* Concentration for effluent outfalls obtained by dividing highest quantity released per day by average monthly flow for that reporting period (with appropriate unit conversion factors).
NOTES: **BOLD** indicates maximum concentration higher than drinking water comparison value (CV). CVs are for perspective only. Outfalls are not used for drinking water. Further evaluation is needed to determine whether releases are of health concern.
MCL = maximum contaminant level LTHA – long term health advisory AL = action level
EMEG = environmental media evaluation guide CREG = cancer risk evaluation guide
(see Appendix B for explanation)
Subscript i represents value based on intermediate exposure duration (2 weeks up to one year).
†Note Virginia DEQ has a water quality criterion of 0.00064 µg/L for PCBs calculated to protect human health from toxic effects through drinking water and fish consumption; this criterion applies in surface water bodies designated as public water supplies, such as the segment of the New River including RFAAP [32]. ATSDR's CREG of 0.018 µg/L accounts only for drinking water exposure.

Although outfalls were within permit requirements, releases represent a unique source of contaminants because the concentration and amounts of several contaminants are higher than normally present in surface waters, result from the processes used at RFAAP, and could potentially cause harmful effects if taken in at high enough levels. Therefore, *effluent and stormwater outfall releases into surface water by RFAAP could be a source of contaminants to the drinking water pathway.* Further evaluation is needed to determine if contaminants in surface water can be transported to a point of exposure and complete the exposure pathway. The transport element is discussed beginning on page 31, after reviewing the available water quality data for points of exposure (private wells and public water supplies) in the next few sections.

Private Wells Near RFAAP- Drinking Water Quality Data

As described previously and shown in Figure 3, many residents around RFAAP rely on drinking water from private wells.

Historical Private Well Data

Testing of private wells is typically the owner's responsibility, and results are not publicly available.

Limited data on private wells in the area were included in a 1992 RFAAP site document [18]. These data were from EPA's STORET (short for STOrage and RETrieval) database of environmental water quality information [33]. ATSDR recently searched the STORET Legacy Data Center, which contains information collected up until the end of 1998 [19]. Using a latitude-longitude rectangle around RFAAP to search, we did not identify any additional wells or well data not included in the 1992 site report. ATSDR also searched more recent data in EPA's "STORET Data Warehouse" for data collected after 1990 and did not identify any additional private well or other groundwater sampling data in this database [34].

The 1992 site report lists 31 private wells within one mile of 3 different points within RFAAP. Data included well information such as depth of well, elevation, and well yield. Not all information was collected/ reported for all wells. Five of the private wells included analytical water quality data (from the 1980s) on parameters such as nitrates and metals. These analytical data are summarized in Table 6.

Most parameters for these 5 private wells were within typical ranges and met primary and secondary water quality standards, with the following exceptions:

- The wells' *hardness* (a measure of the mineral content of the water) was outside typical suggested ranges [35]. Although not always the case, hardness values below the suggested range can cause corrosion problems, and hardness value above this range can cause plumbing, taste, or other nuisance problems.
- Three wells had positive results for total and fecal coliform. In public water systems, positive results for these parameters may be considered acute MCL violations [36]. Positive coliform tests in well water can indicate contamination of the well with surface water or a leaking septic system.
- One well, located almost one mile southwest of the RFAAP border, had the metal cadmium detected at 10 micrograms per liter (µg/L), above the maximum contaminant level of 5 µg/L [36]. Drinking water with this level of cadmium for many years could result in harmful kidney effects. The cadmium detection in this well did not likely result from operations at RFAAP. Only two units at RFAAP, HWMU 7 and HWMU 5, had cadmium detected in groundwater above the MCL. Both of these units are adjacent to the New River, groundwater at the units flows in the unconfined aquifer directly to the river, and the river flows away from the well in question.
- Three wells had sodium levels above EPA's Drinking Water Advisory of 20,000 µg/L [37]. Drinking water with these levels of sodium regularly may contribute excess sodium to individuals on a sodium-restricted diet.

ATSDR does not have information about the historical testing, any actions taken in response to the results, or whether the wells are still in service. Though these historical data are useful, they cannot be used to make firm conclusions about the present state of the wells. Some of the wells discussed above were reportedly located in areas now served by public service authorities. If any of these wells are still in service, the water should be retested and evaluated further.

Table 6. Summary of Historical Sampling Results From Private Wells Near Radford Army Ammunition Plant

Parameter, units reported	Private Well A	Private Well B	Private Well C	Private Well D	Private Well E	Recommended Values, Standards, or Typical Range
Date Sampled	Oct 1984	Aug 1985	Oct 1984	Oct 1984	Jul 1980	-
General Location in Relation to RFAAP Boundary	Less than 0.2 miles east	About 1.5 miles north	About 0.4 miles south	About 0.3 miles south	About 0.9 miles southwest	-
Conductivity, micromhos	477	355	428	626	158	No standard; high values (>1600 µmhos) may indicate a high level of dissolved substances [37]
Chemical Oxygen Demand, mg/L	1	-	1	1	7	No standard; indicator of organic compounds in water
pH, standard units	7.2	7.32	7.7	7.3	-	6.5-8.5 drinking water range
Lab pH, standard units	7.5	7.8	7.2	7.4	7.5	6.5-8.5 drinking water range
Alkalinity, mg/L	206	180	249	331	44	No standard
Oil-Grease-Freon-Grease, mg/L	-	-	-	-	5	No standard; 5 mg/L appears to be the method's detection limit
Ammonia - Nitrogen, mg/L	0.1	0.1	0.1	0.1	0.1	Natural levels usually below 0.2 mg/L [35]
Nitrite - N, mg/L	0.01	0.01	0.01	0.01	0.01	The EPA MCL is 1 mg/L [36]
Nitrate - N, mg/L	0.15	0.5	1	0.06	0.21	The EPA MCL is 10 mg/L [36]
Total Kjedahl Nitrogen, mg/L	0.1	0.1	0.1	0.1	0.1	No standard
Total Phosphorus, mg/L	0.1	0.1	0.1	0.1	0.1	No standard; not a problem in groundwater unless released to surface water [39]
Dissolved Phosphorus, mg/L	0.02	0.01	0.01	0.01	0.01	No standard; not a problem in groundwater unless released to surface water [39]
Total Organic Carbon, mg/L	4	3	3	4	6	No standard
Total Hardness, mg/L						Concentrations >200 mg/L can cause plumbing and nuisance problems; <100 mg/L may cause corrosion problems [35]
Chloride, mg/L	31	10	3	1	6	Concentrations >250 µg/L can cause taste issues [37]
Sulfate, mg/L		22.5	4.11	14.14	15	Concentrations >250 µg/L can cause taste issues [37]
Fluoride, mg/L	0.09	0.13	0.11	0.36	0.7	Concentrations >2 µg/L can cause tooth discoloration [37]
Arsenic, µg/L	-	1	-	-	-	The EPA MCL is 10 µg/L [36]
Cadmium, µg/L	-	1	-	-		EPA MCL is 5 µg/L [36]
Chromium, µg/L	-	1	-	-	10	The EPA MCL is 100 µg/L [36]

Table 6, continued

Copper, µg/L	10	10	10	10	50	EPA AL is 1300 µg/L [36]
Iron, µg/L	80	40	40	200	40	Concentrations >300 µg/L can cause taste, color, and staining issues [37]; RSL for residential tap water is 11,000 µg/L [39]
Lead, µg/L	-	4	-	-	6	The EPA AL is 15 µg/L [36]. There is no safe lead level.
Manganese, µg/L	60	10	40	50	10	Concentrations >50 µg/L can cause taste, color and staining issues. [37]; LTHA is 300 µg/L [41]
Nickel, µg/L	10	10	10	20	10	LTHA is 100 µg/L
Zinc, µg/L	60	60	1,600	960	10	LTHA is 2000 µg/L [41]; concentrations >5000 µg/can cause taste issues [37]
Total Coliform Bacteria, #/100 ml	**2.2**	**2.2**	-	**2.2**	-	Indicates potential for harmful bacteria to be present; water system tests must be negative in 95% or more of samples [36]
Fecal Coliform Bacteria, #/100 ml	**2.2**	**2.2**	-	**2.2**	-	Indicate potential for disease causing bacteria; public systems must take immediate action for any positive result [36]
Mercury, µg/L	-	-	-	-	0.3	The EPA MCL is 2 µg/L [36]
Calcium, µg/L	50,000	39,000	54,000	59,000	17,000	Institute of Medicine Upper Limit is 1,250,000 µg/L [42]
Magnesium, µg/L	25,000	24,000	30,000	40,000	3,000	Institute of Medicine Tolerable Upper Intake is 65,000 µg/L [42]
Potassium, µg/L	1,600	1,700	800	2,000	1,600	Essential element; water would supply less than 1% of adequate intake level [43,35]
Sodium, µg/L	**38,000**	13,000	**37,000**	**46,000**	4,000	EPA Drinking Water Advisory is 20,000 µg/L [37]

Highlighted cells indicate result outside recommended values, standards, or typical range for the parameter of interest
MCL = maximum contaminant level AL = action level LTHA = lifetime health advisory
See Appendix B for further explanation.

Recent Private Well Data

In June and July 2013, the Virginia Chapter of the Sierra Club sponsored testing of a limited number of private wells near RFAAP. The sampling was performed by the New River Valley Sierra Group. The Sierra Club shared the results with ATSDR, and we summarize the findings here.

Five wells were sampled. It is ATSDR's policy not to present identifying information, but the wells sampled were located adjacent to or very close to RFAAP and in various directions from the facility. Sampling procedures were not available. However, a state-certified laboratory performed analyses using various EPA standard methods. Table 7 shows the results [44-46].

As indicated in Table 7, most contaminants were not detected, and those detected met drinking water standards and/or were at concentrations below health-based screening levels. Some contaminants that were detected in RFAAP groundwater, such as the dinitrotoluenes or trichloroethylene, were not detected in private wells near the facility.

These data appear to be collected and analyzed according to standard practices. Although they may not include stringent quality assurance protocols and documentation such as would be required, for example, to use the data to support regulatory enforcement actions, ATSDR believes them to accurately represent condition of the wells at the time of sampling. The results indicate that currently, these wells do not appear to be affected by releases from RFAAP.

Table 7 – Summary of June/July 2013 Private Well Sampling Results (units in micrograms per liter unless noted otherwise)

Compound	Result					Reporting Limit	Noncancer CV and source*	CREG	MCL/ AL
	Well #1	Well #2	Well #3	Well #4	Well #5				
Diesel Components	ND	ND	ND	ND	ND	0.5 mg/L	none	-	none
Arsenic	ND	ND	ND	ND	ND	10	3-EMEG	0.023	10
Barium	33.4	41	ND	85.1	85.8	5	2000-EMEG	-	2000
Cadmium	ND	ND	ND	ND	ND	1	1-EMEG	-	5
Chromium	ND	ND	ND	ND	ND	5	9-EMEG hexavalent chromium	-	100
Cobalt	ND	ND	ND	ND	ND	5	100-iEMEG	-	none
Copper	21.5	8.3	ND	5.7	15.7	5	100-iEMEG	-	1300
Lead	ND	ND	ND	ND	ND	5	15-AL	-	15
Nickel	ND	ND	ND	ND	ND	5	100-LTHA	-	none
Selenium	ND	ND	ND	ND	ND	10	50-EMEG	-	50
Silver	ND	ND	ND	ND	ND	5	50-RMEG	-	none
Zinc	28	ND	ND	77.8	23.4	10	2000-LTHA	-	none
Mercury	ND	ND	ND	ND	ND	0.2	1-RMEG methylmercury	-	2
Butylbenzylphthalate	ND	ND	ND	ND	ND	10	2000-RMEG	-	none
2,4-Dinitrotoluene	ND	ND	ND	ND	ND	10	20-EMEG	0.051	none
2,6-Dinitrotoluene	ND	ND	ND	ND	ND	10	40-iEMEG	0.051	none
Bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	6	600-EMEG	2.5	6
4-Nitrophenol	ND	ND	ND	ND	ND	50	60-LTHA	-	none
Acetone	ND	ND	ND	ND	ND	25	9000-RMEG	-	none
Chloroethane	ND	ND	ND	ND	ND	1	none	-	none
Chloroform	ND	ND	ND	ND	ND	1	100-EMEG	-	none
1,1-Dichloroethane	ND	ND	ND	ND	ND	1	2.4-RSL	-	none
Diethyl ether (ethyl ether)	ND	ND	ND	ND	ND	1	2000-RMEG	-	none
1,1,1,2-Tetrachlorethane	ND	ND	ND	ND	ND	1	70-LTHA	1.3	none
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	1	200-RMEG	0.18	none
Trichloroethene	ND	ND	ND	ND	ND	1	5-EMEG	0.76	5
Cyanide	7.3	ND	ND	ND	ND	5	6-RMEG	-	200
Perchlorate	0.529	0.285	0.357	ND	0.387	0.2	7 - EMEG	-	none
Isopropyl Alcohol	ND	ND	ND	ND	ND	1 mg/L	none	-	none

CV = comparison value
MCL = maximum contaminant level
EMEG = environmental media evaluation guide
RMEG = remedial media evaluation guide
*See Appendix B for further explanation.
CREG = cancer risk evaluation guide
AL = action level
LTHA = lifetime health advisory
RSL = regional screening level

Public Water Systems Near RFAAP- Drinking Water Quality Data

Several public water systems draw surface water from the New River, treat it, and supply to consumers for household use. Monitoring of the water to ensure it meets drinking water standards is required, and annual reports are provided to consumers describing the results of water quality testing. ATSDR examined annual drinking water reports from the water authorities near RFAAP. ATSDR heard particular concerns from the community about the Prices Fork/ Merrimac subsystem within Montgomery County, which uses water collected by RFAAP from within the site boundaries. Therefore, we examined data from this subsystem more closely and summarize it in the next section [11,12].

Prices Fork/ Merrimac

Since late 2003 or early 2004, the Montgomery County PSA has purchased water from RFAAP to serve its Prices Fork/ Merrimac subsystem. The PSA also maintains a connection to the Blacksburg-Christiansburg-VPI Water Authority to use as a backup supply for this subsystem. Before 2004, Prices Fork/ Merrimac was supplied by a well located within the Prices Fork neighborhood and operated by the Montgomery County PSA. A second nearby supply well was taken out of service in mid-2001, after it was determined to be under the direct influence of surface water.

As a public water supply, monitoring of the water to ensure it meets drinking water standards is required. ATSDR examined annual consumer confidence reports summarizing the Prices Fork/ Merrimac drinking water quality from 2001 to 2012. A summary of the reports is presented in Tables 8a (for distribution system testing) and 8b (for consumer tap sampling).

Table 8a. Summary of Prices Fork/ Merrimac Public Water System – Distribution System Sampling, 2001-2012
Reported values in Consumer Confidence Reports, some may be data from previous years if annual monitoring not required.

Parameter Detected	Level Detected												MCL	MCL Goal
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 (Jan-Jun/Jun-Dec)	2011	2012		
Total Organic Carbon (mg/L)	N/A	N/A	N/A	1.1	N/A*	1.0	0.9	0.82	1	1/0.87	0.87	0.56	<2**	N/A
Turbidity (NTU)	N/A	N/A	N/A	0.09 (100%)	0.18 (100%)	<0.09 (100%)	0.11 (100%)	0.08 (100%)	0.39 (97%)	0.08/0.44 (100%/97%)	0.34 (100%)	0.22 (100%)	<0.5 (>95%)	N/A
Combined Radium (pCi/L)	N/A	N/A	N/A	0.4	0.7	0.7	0.4	0.4	0.19	1.4/0.19	0.19	0.49	5	0
Beta Emitters (pCi/L)	1.9	1.9	1.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	0
Alpha Emitters (pCi/L)	1.3	1.3	1.3	0.3	0.3	0.3	0.3	0.3	1.3	N/A/1.3	1.3	1.3	15	0
Chromium (µg/L)	ND	ND	ND	ND	ND	ND	ND	5	ND	ND/ND	ND	ND	100	100
Fluoride (ppm)	0.32	0.3	0.3	ND	ND	ND	ND	0.07	0.12	0.67/0.07	ND	0.13	4	4
Nitrate-Nitrite (mg/L)	0.1	0.07	N/A	1.05	0.96	0.61	0.79	0.62	3	0.95/0.83	0.89	1.1	10	10
Barium (mg/L)	0.2	0.21	0.21	ND	ND	ND	ND	ND	ND	0.024/0.026	0.021	0.0271	2	2
Chlorine (mg/L)	N/A	N/A	N/A	1.22	0.98	1.08	1	1.43	1.42	1.39	1.28	1.26	4	4
Haloacetic Acid (µg/L)	N/A	N/A	N/A	85.3†	48.7‡	41	41.4	50	59	39	43	40	60	N/A
Total Trihalo-methanes (µg/L)	N/A	N/A	N/A	116†	67.8‡	68	58.5	56	68	62	71	66	80	N/A

NOTE: Water source for the subsystem was switched from well water to RFAAP with a backup connection to the Blacksburg-Christiansburg-VPI (BCV) water authority at the end of 2003. In 2010, BCV provided water from January to June, and RFAAP supplied water from July to December. The two suppliers use different treatment methods, so parameter findings are presented for each supplier separately. N/A = Not Measured ND = Not Detected

* Violation - Failure to monitor TOC/alkalinity during August 2005 prevented 12-month average from being calculated.

** Alternative compliance criteria of TOC less than 2.0 mg/L calculated quarterly as a running annual average.

† Less than 12 months of data available, so no standard to compare for violations.

‡ Violations during 12-month monitoring periods July 2004 to June 2005 and April 2004 to March 2005. Changes made to distribution system and disinfection levels.

Table 8b. Summary of Prices Fork/ Merrimac Public Water System – Consumer Tap Sampling, 2001-2012

Reported values in Consumer Confidence Reports, some may be data from previous years if annual monitoring not required.

Parameter Detected	Level Detected												Action Level / MCL	MCL Goal
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012		
Lead (µg/L), 90th percentile (# of taps exceeding AL)	5 (0)	9 (1)	9 (1)	<5 (0)	<5 (0)	-	-	3 (0)	3 (0)	3 (0)	21 (4)*	3.7 (0)	15	0
Copper (mg/L), 90th percentile (# of taps exceeding AL)	0.098 (0)	0.184 (0)	0.184 (0)	0.006 (0)	0.064 (0)	0.064 (0)	0.064 (0)	0.037 (0)	0.037 (0)	0.037 (0)	0.137 (0)	-	1.3	1.3
Coliform	0	0	-	0	2†	-	-	-	-	1 (0 after resampling)	-	-	0	0
Fecal Coliform	0	0	-	0	0	-	-	-	-	0	-	-	0	0

"-" means no result reported

* Four homes exceeded lead action level. Each home was resampled and none of the homes exceeded the action level after resampling.

† Violation – Two samples from same site tested positive for coliform. After flushing the household plumbing, repeat samples indicated no coliform present. Samples upstream and downstream showed no coliform.

The Prices Fork/Merrimac subsystem generally meets water quality standards. Occasional violations did occur and are discussed below:

- In August 2005, RFAAP failed to collect and analyze samples for total organic carbon and alkalinity, preventing an annual running average from being collected. This was a violation, though data from before and after this event suggested that TOC and alkalinity concentrations were not out of compliance. No further violations for this parameter have occurred.
- In 2005, the system was in violation for haloacetic acid and total trihalomethanes (water treatment residuals) for the 12-month reporting periods July 2004 to June 2005 and April 2004 to March 2005. Changes were made in the disinfectant levels in the distribution system to address this problem. There have been no further violations.
- The PSA conducts regular monitoring of consumer tap water by having homeowners collect water samples and return them to the PSA. In 2011, this monitoring found that in 4 homes, the action level for lead was exceeded. The 90th percentile of lead concentrations was higher than the action level, constituting a violation. In response to the situation, PSA officials met with the homeowners to discuss the results, and each home's water was resampled. None of the homes exceeded the action level for lead upon resampling. This could mean that sampling error was responsible for the initial detections. Lead can enter a home's drinking water by leaching from pipes, fittings, or solder joints in the home system, and even very low levels can be of health concern. RFAAP cannot be the source of these detections because lead has not been detected in any distribution system sampling. (Although all regulated contaminants are tested for, consumer confidence reports typically only present results for detected contaminants.)

Other Public Water Systems Near RFAAP

ATSDR reviewed water quality reports available on the other public water systems near RFAAP. We also reviewed water quality information on public systems and small community systems compiled in a 2009 report by the Environmental Working Group and reported by the New York Times [47,48]. Many of the systems had no detections or violations; several had occasional low detections of lead, copper, or disinfection byproducts.

Transport Element of Drinking Water Pathway

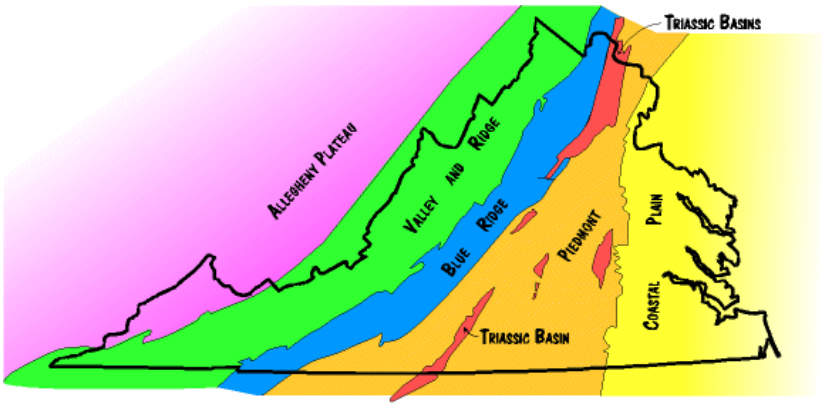
Local Geology and Topography

Site geology has been described in detail in several documents, including a dye-tracing study report from 1994 [49], a RCRA Facility Investigation for several solid waste units from 1996 [50], the Final Master Work Plan for the site from 2003 [51], and a draft report on current conditions of groundwater at the Horseshoe Area from 2005 [52]. ATSDR reviewed the information provided in these and other documents. Please see the list of references not cited beginning on page 49 for a list of general references. Table A.5 in Appendix A summarizes local geology and measured local groundwater flow patterns for the individual units at RFAAP investigated and listed in the groundwater discussion earlier in this document (Table 1). This information was obtained from the numerous site-specific reports available through the RFAAP Installation Restoration Program website and other sources.

It is beyond the scope of this health consultation to reiterate the detailed descriptions in these documents on the complex geology existing at the site. The following discussion gives a brief summary of our interpretation of these studies, which we have attempted to make accessible to the lay reader.

RFAAP lies in the *Valley and Ridge* physiographic province (see illustration below) [53]. This is an area of more than 10,000 square miles running through western Virginia. Hundreds of millions of years ago, rocks in this area were formed by sedimentation of ocean minerals. Over millions of years, changing ocean levels coinciding with periods of increased tectonic forces deep within the earth deformed the sedimentary rocks, bending (*folding*) and breaking (*faulting*) them and pushing them up to form hills and mountains. At the same time, the rocks were being eroded at various rates by water and wind flowing over them. The combination of these forces resulted in the characteristic northeast/ southwest trending ridges and valleys that give the province its name.

Figure 6. Provinces of Virginia. Valley and Ridge shown in green, with RFAAP area shown by black box. Modified from [53].



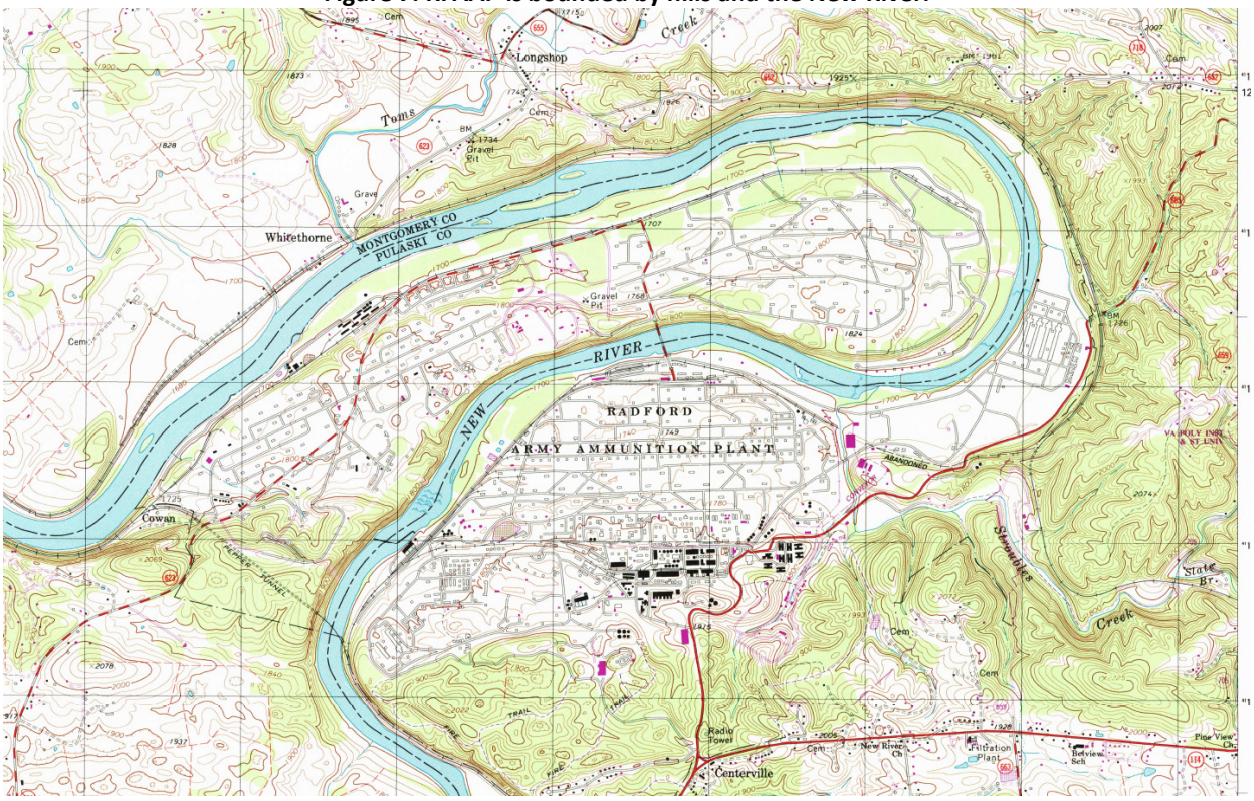
RFAAP lies in the south Appalachian region of the province, within and around a horseshoe-shaped bend of the New River. Contrary to its name, the New River is thought to be one of the oldest in the world. It probably existed before the surrounding hills and mountains were formed, because its channel actually cuts through ridges rather than flowing around them. The southern Appalachian region of the Valley and Ridge province has rocks that are generally *carbonate* in form (made of minerals with carbonate (CO_3^{2-}) groups, mainly limestone and dolomite). This region is also a transition zone where the main forces acting on rock change from folding to faulting, and parts of RFAAP and its surroundings are within a fault zone. Much of the underlying rock in the area is highly fractured. Physical and chemical conditions have allowed groundwater to dissolve the carbonate minerals from fractures and bedding planes, resulting in a *karst* geology characterized by wide groundwater flow channels, sinkholes, and features such as caves.

The bedrock comes all the way to the ground surface (outcrops) in many areas at RFAAP. In other areas, the bedrock is covered with loose *overburden* materials, rocks, and soil that can range anywhere from 0 to 70 feet in depth. Overburden can include silt, clay, and sand like materials deposited by rivers or creeks, silts and clays from in-place weathering of bedrock, or materials washed to other locations.

RFAAP lies on land sloping down towards and within the floodplain of the New River. The facility is bordered on the west, south, and east sides by wooded hills and bluffs. Figure 7 illustrates this. A

tributary to the New River, Stroubles Creek, also flows into the southeast side of RFAAP and joins the New River.

Figure 7. RFAAP is bounded by hills and the New River.



Surface Water Flow

The major surface water features at RFAAP are the New River and Stroubles Creek. The New River enters the site at its southwest border, flows east and then turns west before exiting the site at its northwestern edge. Stroubles Creek enters the site from the southeast and joins the New River just before its bend.

Water on the ground's surface flows from higher to lower elevation. The New River represents the lowest elevation in the area. All surface water eventually reaches the New River. Rain falling on the site flows downhill, either to smaller creeks or manmade runoff channels which eventually join either Stroubles Creek or the New River.

Groundwater Flow

Groundwater is present in fractures and solution cavities of the bedrock. In certain areas, low permeability layers in the overburden can keep groundwater perched above the bedrock in the pore space of the unconsolidated sediment. The characteristics of the bedrock and overburden are variable throughout the site, so groundwater conditions vary as well. As mentioned previously, unit-specific groundwater flow patterns as determined in numerous site investigations are tabulated in Appendix A.5. This table illustrates the variability and identifies where karst groundwater flow conditions exist.

The most detailed investigation of groundwater at the site was the 2005 report on groundwater conditions at the Horseshoe Area [52]. The study also discussed some features of groundwater flow from the South Area of RFAAP. ATSDR concurs with the findings listed below.

- The New River is the dominant flow system.
- Levels in bedrock groundwater wells support the theory that karst features developed along pre-existing weaknesses toward the river.
- Groundwater flow at RFAAP occurs in the overburden (unconsolidated

Groundwater Flow and Karst

Groundwater is an integral part of the endless circulation of water between ocean, atmosphere, and land (the *hydrologic cycle*). Rain falls onto ground and some of it infiltrates down to the groundwater (*recharge*). The groundwater moves though the subsurface and eventually *discharges* from the ground to evaporate or enter streamflow. Movement of groundwater is complicated, but a basic tenet of flow is stated in the classic text on Groundwater by Freeze and Cherry [54]: "The only immutable law is that highlands are recharge areas and lowlands are discharge areas." That is, elevation is the major driving force for recharge and discharge of groundwater, and groundwater, like surface water, tends to flow to lower elevations.

The actual flow of groundwater is not always directly from high to low elevation, though. The water takes the easiest path to reach its destination, and depending on the characteristics of the rock materials it encounters, may not follow a straight route. Groundwater can be effectively stopped if it hits an area of low permeability, like a clay layer or very dense bedrock. Fractures in bedrock, then, represent a route groundwater would prefer to take in a very dense rock. If the groundwater can find an outlet at the other end (a spring or other stream), groundwater flow can occur through the fractures.

This is how karst forms. Groundwater flows through fractures in soluble bedrock (e.g., limestone or dolomite) and slowly reacts with the minerals in the rock. Little by little, the rock on the walls of the fractures dissolves into the flowing groundwater and is carried away. This can form channels, voids that cause sinkholes, and caves. The flow through these channels can be very fast and high-volume. Formation of karst features occurs mostly around the water table, because groundwater is easily saturated with dissolved rock compounds and its ability to dissolve rock will decrease the deeper it goes (the longer it contacts the rock).

sediments) down to the less-permeable bedrock. The groundwater will then flow in a downgradient direction (to the New River) either via fractures or permeable conduit in the bedrock or through the unconsolidated sediments.
- Faults associated with the Pulaski thrust fault (running east-west across the site) are suspected barriers to groundwater flow based on observed clustering of springs and dye trace test results.

Pathway Analysis for Surface Water Releases

As discussed previously, RFAAP releases various contaminants in permitted outfalls into the New River or Stroubles Creek. Other facilities, including the Peppers Ferry Regional Wastewater Treatment Plant and the Blacksburg Christiansburg Wastewater Treatment Plant, also discharge treated water to the New River in the vicinity of RFAAP. All local drinking water intakes are upstream of the RFAAP and other outfalls. Figure 5 shows the closest drinking water intakes, RFAAP and Blacksburg-Christiansburg-VPI Water Authority, both upstream of any outfall from the facility. Further away, the Radford City drinking water intake is to the southwest of the city, about 10 river miles upstream, and Pulaski County's water intake is at Claytor Lake, about 13 river miles upstream from RFAAP. ATSDR obtained river segment data from VDEQ's Virginia Environmental Geographic Information Systems (VEGIS) viewer and found no drinking water intakes downstream of the facility for 40 river miles downstream to the Virginia/ West Virginia border [10].

It is physically impossible for substances released to move upstream, against the flow of the New River, to affect any drinking water intakes located upstream. Therefore, surface water releases cannot affect public drinking water supplies drawn upstream from the New River. The drinking water pathway between RFAAP surface water releases and public water intakes upstream is *incomplete*.

Before 2007, a second drinking water intake existed at RFAAP, downstream from most outfalls at the facility (see Figure 5). This water was treated at a former drinking water treatment plant and sold to Pulaski County to help supply the areas of Belspring, Parrot, and Fairlawn near RFAAP [13,33]. Because outfall contaminants could have been in the withdrawn water, this would constitute a potential past exposure pathway. However, ATSDR does not consider this exposure to have been a health concern for the following reasons:

- TRI reports suggest that the quantities of contaminants released prior to 2009 were similar to or lower than more recent releases [28]. Comparing outfall volumes and river flow volumes shows that upon mixing with river water, outfall contaminant concentrations would be reduced by a factor of at least one thousand, and probably much more [27,55]. (See Table 9.) Based on the highest detections of various contaminants from Table 5, resulting concentrations of contaminants detected would be reduced to concentrations below drinking water screening levels.
- Complete mixing would have occurred due to the greater than 3 miles of river flow between the most downstream outfall and the drinking water intake.
- The water would have undergone quality testing required for public water supplies. However, ATSDR did not have access to reports specific to the RFAAP-collected water from this time period.

All use of water from the second RFAAP intake was discontinued in 2007.

Table 9. Volumes of RFAAP Reported Effluent Discharges Compared to New River Flow

	Average Flow in Million Gallons per Day (MGD)	Highest Average Flow in MGD	Lowest Average Flow in MGD
Sum of all RFAAP Effluent Outfalls*	15	22	9
New River**	92,815	1,497,273	23,052
* Calculated from VADEQ Discharge Monitoring Reports, 6/2009 through 1/2013, based on monthly average flows. ** USGS Flow Data from Gauge New River at Radford, available at waterdata.usgs.gov, data calculated from daily average flow data from 6/1/2009 through 1/31/2013 Note: Stormwater releases for precipitation events are variable and only a fraction of effluent releases, so they are not included.			

The dilution of contaminants in the river, as described above, also means that surface water releases cannot affect groundwater or private wells downstream of RFAAP. As was discussed above, groundwater in the area tends to flow towards the New River. (This would be true of both sides of the river, not just the RFAAP side). However, under certain conditions (such as flood events or severe drought), the river level can be higher than the groundwater table and therefore water would move from the riverbed into the groundwater. The conditions would have to last long enough for the river water to be pushed all the way to a point where a nearby well could intercept it. In the unlikely circumstances that all this happened, the contaminants from RFAAP surface water releases would have been diluted or otherwise attenuated to concentrations too low to have any measureable effect on drinking water quality in the well.

Pathway Analysis for Groundwater Contaminants

Groundwater at certain locations beneath RFAAP was found to have contaminants at levels above health-based drinking water comparison values. No one uses groundwater at the facility for drinking. A mention of two former supply wells located in the Horseshoe Area and the South Area appeared in some site reports dated between 1987 and 2005 [56,18,52]. Little information is known about former use of these wells. A 1992 report lists them as standby wells [18], and a 2005 report states that the well in the Horseshoe Area was formerly used for fire suppression and human consumption, but had been abandoned [52]. No more detailed information on the use of these wells or their current status has been found.

Since the groundwater is not used for drinking at RFAAP, for any drinking water exposure to occur, the contaminants would have to travel through the ground to a point where a well intercepts the water. The geology and groundwater flow at individual units at RFAAP have been described in historical reports available on the Installation Restoration Program Online information repository. These descriptions have been compiled and summarized as Table A.5 in Appendix A. Our evaluation and interpretation of these findings is given here.

- In general, the groundwater at the site is “unconfined,” that is, its surface (the “water table”) is at atmospheric pressure. That means the groundwater is not trapped between “confining units” that could build up pressure and cause the groundwater to flow contrary to its normal “downhill” flow to reach a lower hydraulic head.

- The units and study areas in the New River floodplain generally have groundwater in the river sediments above the bedrock, and the groundwater flow has been measured to move slowly towards the New River.
- The bedrock in most areas of the site is a weathered and fractured carbonate rock type.
    - In some areas (notably the SWMU 17/40/71/Former Lead Furnace areas on the south side of RFAAP and the central Horseshoe Area), many karst features including voids and fractures exist. Fractures and wide solution channels may not be oriented in the direction of the shortest flow path. However, the eventual destination for the groundwater is always towards a lower hydraulic head, in this case towards local "discharge" areas including springs, seeps, Stroubles Creek, and the New River.
    - In other areas the fractures are filled with mineral material or clays such that no low resistance channels remain. In these areas, the groundwater flow is similar to that in unconsolidated sediment and follows the topography from high to low.
- Groundwater flow in the karst area around the SWMU 17/40/71/Former Lead Furnace area was investigated in September 1993 using a dye tracer test to monitor dye flow from 2 different injection points [49]. Two different dyes were injected at two sinkhole points thought most likely to transmit water to the karst flow system. Detectors for the dyes were located at 35 different monitoring wells, springs, and river locations around the injection points (both on-site and off-site) to map where the dye went after entering the karst system.
    - The first injection point dye was detected most strongly at a spring on the New River almost a mile due west of the injection point and at 2 river monitoring points downstream from the spring. No detections occurred at any other monitoring point. The flow path was aligned with a west-northwest to east-southeast trending fracture identified in previous studies.
    - The second injection failed. Neither flushing water nor dye could be pumped into the injection well; instead they were pumped onto the ground above the injection well. A clay layer observed in the overburden apparently kept the dye from entering the karst formation, because no dye was detected over the 3 month test period in any of the 35 on-site and off-site monitoring points.

  The September 1993 study represented relatively low flow conditions. The dye trace study was repeated for the first injection point in April 1994 under higher flow conditions [49]. After this injection, the dye was detected only at the same spring on the New River west of the injection point. Sampling for the dye from the September 1993 second injection again showed no detections.
- Some areas of groundwater contamination exist at RFAAP, and the contaminant levels are in some cases higher than health-based drinking water standards. However, detected contaminant levels and distributions in HWMUs and SWMUs have been well characterized. Several units are subject to ongoing monitoring requirements or have been approved as cleaned up per regulatory agencies. ATSDR determined that the involved agencies have thoroughly identified and characterized possible groundwater contamination at RFAAP.

- Groundwater throughout the site flows toward local discharge points with lower hydraulic head, springs or surface water. The karst area on the southern side of the site was investigated and found to discharge to the New River on site. No private wells are located within likely flow paths of the groundwater, and wells in the area do not have high enough pump rates to affect groundwater flow paths on opposite sides of rivers or hydraulic divides on hills and ridges.
- It should also be noted that groundwater beneath land on the opposite side of the New River would also tend to flow towards the river. Most private wells are located across the river from RFAAP, so the water drawn from these wells is likely flowing from upgradient locations even further away from RFAAP. Private well yields (that is, the gallons per minute of water the well can provide) reported in the historical information from STORET are 5-40 gallons per minute. The average flow rate of the New River is over 60 *million* gallons per minute. Compared to the New River, private well pump rates have little effect on groundwater flow, especially close to the river.
- Groundwater that discharges into surface waters leading to the New River would be quickly dispersed, diluting any contaminant concentrations to levels below health-based drinking water comparison values. Most groundwater would enter the New River downstream of surface water intakes, as well. It would be physically impossible for diluted contaminants to re-concentrate further downstream.

In summary, groundwater flow patterns are directed by local geology and surface water influences. The combined weight of evidence from geologic studies, dye tracer studies, and contaminant investigations conducted at RFAAP indicate that nearby private wells could not be affected by site-related contaminants. This conclusion is supported by recent testing of private wells near the site. The drinking water pathway is *incomplete* for groundwater contamination at RFAAP.

Community Concerns

In conducting public health activities, ATSDR attempts to respond to communities' health concerns about the site. ATSDR was contacted by community members by telephone and e-mail with concerns about the site. ATSDR also met with community members in a public availability session held in January 2013. A local environmental group shared responses from a health survey conducted by mail in the area surrounding RFAAP in winter and spring 2013. ATSDR also obtained community concerns shared by stakeholders with a history of work at the site. Residents expressed concerns about a number of issues; specific concerns are listed in Appendix D of this report. Those concerns related to drinking water, the focus of this report, are summarized here.

Concerns about smell and appearance of well water and whether it is safe to drink

ATSDR found that private wells in the area surrounding RFAAP are not affected by contaminants from the facility. However, drinking water wells are sensitive to a number of different factors. Well construction, naturally occurring substances in bedrock, and surface water flowing through local karst formations can all affect quality of the water obtained from wells. ATSDR recommends well owners have their well water tested periodically to ensure it is of good quality. For more information about well maintenance and treatment, visit Centers for Disease Control and Prevention's (CDC) website for "Private Ground Water Wells" (http://www.cdc.gov/healthywater/drinking/private/wells/index.html) or the Virginia Department of Health's Private Well Water Information web page

(http://www.vdh.state.va.us/environmentalhealth/onsite/regulations/PrivateWellInfo). The Virginia Cooperative Extension Service also has several publications on water quality and best practices for well maintenance on their website at http://www.pubs.ext.vt.edu/category/home-water-quality.html.

Concerns that water supplied to Montgomery County by RFAAP is contaminated
ATSDR found that the water supplied to Montgomery County's Prices Fork/ Merrimac subsystem meets drinking water requirements. Because the water is drawn from the New River upstream of any RFAAP or municipal outfalls, it cannot be affected by contaminants released from those facilities. In 2011, regular consumer tap sampling found a few homes in the subsystem that exceeded the action level for lead. However, lead was not found in the distribution system. Resampling of the affected homes found lead concentrations below the action level.

Conclusions

ATSDR reached two conclusions in this health consultation:

First, *public water systems in the area are not affected by releases from RFAAP*. Therefore, contaminants from RFAAP in drinking water from public water systems cannot harm people's health. The basis for this conclusion is:

- Public water authorities in the area obtain drinking water from the New River or Claytor Lake, upstream of RFAAP processing areas and wastewater outfalls. Contaminants cannot physically flow upstream, so there is no way for them to enter these systems. Drinking water quality in local public water systems meets regulatory requirements for safe drinking water.
- Contaminants entering the New River from the facility (in wastewater, stormwater, or groundwater) would be diluted or otherwise attenuated by the large river flow to concentrations below health-based guidelines for drinking water. Thus, a former drinking water intake that operated before 2007 downstream of RFAAP, and any past or current intakes far downstream of RFAAP would not likely be affected by contaminants from the facility.

Second, *private wells near RFAAP are unlikely to be affected by releases from the facility*. Therefore, contaminants from RFAAP in drinking water from private wells near RFAAP are unlikely to harm people's health. The basis for this conclusion is:

- Groundwater at RFAAP does contain areas with high levels of some contaminants. Those contaminated areas have been characterized and are monitored regularly.
- The available data and principles of groundwater flow indicate that all groundwater at the site discharges to the New River. Once there, any contaminants in groundwater would be diluted or otherwise attenuated by the large river flow and could not re-concentrate in groundwater downstream.
- No private wells are located within likely flow paths of the groundwater, and wells in the area do not have high enough pump rates to affect groundwater paths.

- Quality of water in private wells in the area, though not affected by RFAAP, may be affected by contaminants from surface water or other local sources due to the local geology.

Recommendations

- ATSDR does not have site-specific recommendations for well testing since this evaluation showed private wells are unlikely to be affected by RFAAP. However, ATSDR recommends that all private well users monitor the quality of their private water well. Information and recommendations for private well testing can be found at the Virginia Department of Health's Private Well Water Information web page (http://www.vdh.state.va.us/environmentalhealth/onsite/regulations/PrivateWellInfo) and in articles on home water quality available from the Virginia Cooperative Extension Service (http://www.pubs.ext.vt.edu/category/home-water-quality.html).

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Appendix A. Supplemental Tables for Groundwater Data

Table A.1. Summary of Groundwater Data Available for Various Units at Radford Army Ammunition Plant

Groundwater Sampling Area	Description/ Notes	Date of Sampling [Reference]	What was Tested For?*											
			Water quality indicators	Cyanide	Perchlorate	Metals/ Inorganics	Explosives	Pesticides	Herbicides	Volatile Organic Compounds	Semivolatile Organic Compounds	Polyaromatic Hydrocarbons	Polychlorinated Biphenyls	Dioxins/ Furans
Units Studied, South Area of MMA, Along River, From West to East														
SWMU 46	Waste Propellant Disposal Area (PCE and daughter products only)	2006 [57]								×				
HWMU 7	Former Surface Impoundment	1985 [58]	×			×								
HWMU 7	Former Surface Impoundment (compliance monitoring specified in permit)	2008-2012 [59-63]	×	×		×		×		×	×			
SWMU 37	Calcium Sulfate Drying Bed	2008 [64]	×		×	×	×	×		×				
SWMU 9	C-line nitrocellulose wastewater	1980 [56]	×			×								
SWMU 38 & Area Q	Calcium Sulfate Drying Bed & Abandoned Lagoon Used for Calcium Sulfate Disposal	2008 [64]			×	×	×	×		×				
SWMU 45	Sanitary Landfill	1991 [65]	×			×	×			×	×			
SWMU 45	Sanitary Landfill	2008 [65]	×	×	×	×	×			×				
Area F	Drum/ Container Storage Area (Chromium only metal tested)	2006 [57]				×		×						
Area P	Scrap Metal Salvage Yard	2007 [66]			×	×	×	×	×	×	×	×	×	
HWMU 10	Former Equalization Basin for Biological Treatment Plant	1990 [67]		×		×				×	×			
HWMU 10	Former Equalization Basin for Biological Treatment Plant (compliance monitoring specified in permit)	2008-2012 [59-63]	×	×		×		×		×	×			
HWMU 10 & SWMU 35	Former Equalization Basin for Biological Treatment Plant & Calcium Sulfate Drying Bed	1991 [68]	×			×	×			×	×			

Table A.1, continued

Groundwater Sampling Area	Description/ Notes	Date of Sampling [Reference]	What was Tested For?*											
			Water quality indicators	Cyanide	Perchlorate	Metals/ Inorganics	Explosives	Pesticides	Herbicides	Volatile Organic Compounds	Semivolatile Organic Compounds	Polyaromatic Hydrocarbons	Polychlorinated Biphenyls	Dioxins/ Furans
SWMU 35	Calcium Sulfate Drying Bed (chromium and lead only metals tested)	1993 [64,69]	×			×	×							
SWMU 35	Calcium Sulfate Drying Bed	2008 [64]	×		×	×	×	×		×	×			
SWMU 8	AB-Line acidic wastewater	1980 [56]	×			×								
SWMU 43	Sanitary Landfill	1991 [68]				×				×	×			
Units Studied, South Area of MMA, Away (>500 ft) From River, Generally From West to East														
Oleum Plant	Former Oleum Plant	2007 [70]			×	×	×	×		×	×			
SWMU 6	Acidic Wastewater Lagoon	1992 [68]				×								
SWMU 40	Sanitary Landfill Nitroglycerine Area	1995 [50]	×			×	×							
SWMU 40	Sanitary Landfill Nitroglycerine Area	2007 [71]	×		×	×	×	×		×	×			
SWMU 40	Sanitary Landfill Nitroglycerine Area	2011-2013 [72,73]	×		×	×		×		×	×			×
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	1995 [50]	×			×	×							
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	2007 [71]	×		×	×	×	×		×	×			
FLFA	Former Lead Furnace Area	2007 [74]			×	×	×	×	×	×	×	×	×	×
HWMU 5	Former Surface Impoundment	1983-1984 [58]	×			×		×						
HWMU 5	Former Surface Impoundment (compliance monitoring specified in permit)	1996-2012 [75,59-63]	×	×		×		×		×	×			

Table A.1, continued

Groundwater Sampling Area	Description/ Notes	Date of Sampling [Reference]	What was Tested For?*											
			Water quality indicators	Cyanide	Perchlorate	Metals/ Inorganics	Explosives	Pesticides	Herbicides	Volatile Organic Compounds	Semivolatile Organic Compounds	Polyaromatic Hydrocarbons	Polychlorinated Biphenyls	Dioxins/ Furans
HWMU 5	Former Surface Impoundment	2009 [76]	×			×	×			×	×		×	
Area O	Underground Fuel Oil Spill	1992 [77]								×	×			
Area O	Underground Fuel Oil Spill	1993 [78]	×								×			
Area O	Underground Fuel Oil Spill	2007 [79]								×	×	×		
HWMU 4	Acidic Wastewater Lagoon	1984 [56]	×											
SWMU 41	Red Water Ash Landfill	1992 [68]				×	×				×			
Units Studied, Horseshoe Area of MMA, Western														
SWMU 31	Coal Ash Settling Lagoons	1998, 2008 [80]										×		
SWMU 57	Former Acid Settling Pond	2008 [81]	×		×	×		×		×	×			
SWMU 57	Former Acid Settling Pond	2010 [82]	×			×				×				
Units Studied, Horseshoe Area of MMA, Central														
SWMU 39	Incinerator Wastewater Ponds	1993 [83]				×					×			
SWMU 39	Incinerator Wastewater Ponds (compliance monitoring of specific contaminants)	2003-2007 [84]	×			×	×	×			×			
SWMU 32	Inert Waste Landfill	1992 [68]				×				×	×			
SWMU 26	Fly Ash Landfill	1992 [68]				×				×	×			
Units Studied, Horseshoe Area of MMA, Eastern														
SWMUs 28, 51 & 52	Sanitary landfill; TNT Neutralization Sludge Disposal; Closed Sanitary Landfill	1992 [75]				×	×			×	×			

Table A.1, continued

Groundwater Sampling Area	Description/ Notes	Date of Sampling [Reference]	What was Tested For?*											
			Water quality indicators	Cyanide	Perchlorate	Metals/ Inorganics	Explosives	Pesticides	Herbicides	Volatile Organic Compounds	Semivolatile Organic Compounds	Polyaromatic Hydrocarbons	Polychlorinated Biphenyls	Dioxins/ Furans
HWMU 16	Closed Hazardous Waste Landfill (compliance monitoring specified in permit)	2003-2012 [59-63]	×	×		×		×		×	×			
HWMU 16	Closed Hazardous Waste Landfill	1982-1984 [58]	×			×		×		×				
SWMUs 27 &29	Calcium Sulfate Landfill & Fly Ash Landfill #2	1985 [56]	×			×								
SWMU 27, 53, 29	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1985, 1991, 1992 [68]	×			×					×			
SWMUs 27, 29 & 53	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1993 [85]				×				×	×			
SWMU 50	Calcium Sulfate Disposal	2007 [86]			×	×	×	×	×	×	×	×	×	×
SWMU 51 Vicinity	TNT Neutralization Sludge Disposal; Hazardous Waste Landfill, Oily Wastewater Disposal, Red Water Ash Disposal, Bottom Ash Pile	2006-2007 [87]			×	×	×	×	×	×	×	×	×	×
SWMU 74	Inert Landfill	1991 [68]				×								
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1992 [68]				×	×			×	×			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1995, 1997 [88]				×	×			×	×			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1999 [88]			×	×	×			×	×			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2003-2004 [89]	×		×	×	×				×			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2007 [89]			×		×							×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2002 [90]			×		×							

Groundwater Sampling Area	Description/ Notes	Date of Sampling [Reference]	What was Tested For?*											
			Water quality indicators	Cyanide	Perchlorate	Metals/ Inorganics	Explosives	Pesticides	Herbicides	Volatile Organic Compounds	Semivolatile Organic Compounds	Polyaromatic Hydrocarbons	Polychlorinated Biphenyls	Dioxins/ Furans
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2004 [90]			×		×							
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2011-2012 [91,92]			×		×							
HWMU/ SWMU 13	Open Burning Ground	1991 [75]	×			×	×			×	×			
HWMU/ SWMU 13	Open Burning Ground (compliance monitoring specified in permit)	2003-2014 [93-96]		×	×	×		×		×	×		×	×

*Note Analyses are not necessarily exclusive. For example, polyaromatic hydrocarbons and some explosive compounds are also detected with semivolatile organic compound analysis.

Table A.2a. Detections of Metallic, Inorganic, and Explosive-Related Contaminants in Groundwater at Specific Units at Radford Army Ammunition Plant

			Metals/Inorganics																							Explosives Related Compounds																	
Area of Groundwater Sampling	**Description**	**Date of Sampling**	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Vanadium	Zinc	Chloride	Fluoride	Nitrate	Sulfate	Cyanide	Perchlorate	2-Amino-4,6-dinitrotoluene	4-Amino-2,6-dinitrotoluene	Aminodinitrotoluene	1,3-Dinitrobenzene	2,4-Dinitrotoluene	2,6-Dinitrotoluene	Dinitrotoluene	HMX	Nitrobenzene	o- (2-) Nitrotoluene	p- (4-) Nitrotoluene	RDX	Tetryl	1,3,5-Trinitrobenzene	2,4,6-Trinitrotoluene
Units Studied, Southern Area of MMA, Along River, From West to East																																										
SWMU 46	Waste Propellant Disposal Area (PCE and daughter products only)	2006																																								
HWMU 7	Former Surface Impoundment	1985			×	×		×	×			×	×	×	×		×				×	×	×	×																		
HWMU 7	Former Surface Impoundment	2008-2012				×			×	×	×		×			×				×																						
SWMU 37	Calcium Sulfate Drying Bed	2008	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×							×	×		×		×										
SWMU 9	C-line nitrocellulose wastewater	1980										×		×								×	×	×																		
SWMU 38 and Area Q	Calcium Sulfate Drying Bed & Abandoned Lagoon Used for Calcium Sulfate Disposal	2008	×		×	×		×	×	×	×	×	×	×		×			×	×																					
SWMU 45	Sanitary Landfill	1991				×						×	×	×																												
SWMU 45	Sanitary Landfill	2008	×	×	×	×		×	×	×	×	×	×	×		×	×	×	×	×					×																	
Area F	Drum/ Container Storage Area (Chromium only metal tested)	2006							×																																	
Area P	Scrap Metal Salvage Yard	2007	×			×	×		×	×	×	×	×	×	×	×	×	×	×	×																					
HWMU 10	Former Equalization Basin for Biological Treatment Plant	1990																																							
HWMU 10	Former Equalization Basin for Biological Treatment Plant	2008-2012				×			×		×		×						×	×																					
HWMU 10 & SWMU 35	Former Equalization Basin for Biol.Treatment Plant & Calcium Sulfate Drying Bed	1991	×	×	×	×			×	×	×	×	×	×		×		×	×	×			×	×							×	×		×				×			
SWMU 35	Calcium Sulfate Drying Bed (chromium and lead only metals tested)	1993							×				×										×											×							
SWMU 35	Calcium Sulfate Drying Bed	2008	×	×		×		×	×	×	×	×	×	×		×		×	×	×														×							
SWMU 8	AB-Line acidic wastewater	1980										×		×								×	×	×																	
SWMU 43	Sanitary Landfill	1991			×	×						×		×																											
Units Studied, Southern Area of MMA, Away (>500 ft) From River, Generally From West to East																																									
Oleum Plant	Former Oleum Plant	2007	×			×				×		×		×		×				×						×					×	×		×	×			×			
SWMU 6	Acidic Wastewater Lagoon	1992				×			×																																
SWMU 40	Sanitary Landfill Nitroglycerine Area	1995				×																																			
SWMU 40	Sanitary Landfill Nitroglycerine Area	2007		×		×			×	×	×	×	×	×	×	×	×		×	×						×															
SWMU 40	Sanitary Landfill Nitroglycerine Area	2011-2012	×		×	×	×		×	×	×	×	×	×	×	×	×		×	×						×															
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	1995		×		×	×						×				×																								
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	2007		×		×			×	×	×	×		×		×				×						×															
FLFA	Former Lead Furnace Area	2007	×			×	×		×	×	×	×	×	×	×	×	×	×	×	×						×															
HWMU 5	Former Surface Impoundment	1983-1984			×	×		×	×			×	×	×	×						×		×	×																	
HWMU 5	Former Surface Impoundment	1996-2012				×	×	×	×	×	×		×			×	×			×			×	×							×				×						
HWMU 5	Former Surface Impoundment	2009	×		×	×	×		×	×	×	×	×	×		×			×	×																					
Area O	Underground Fuel Oil Spill	1992																																							
Area O	Underground Fuel Oil Spill	1993																					×																		
Area O	Underground Fuel Oil Spill	2007																																							
HWMU 4	Acidic Wastewater Lagoon	1984																					×	×																	
SWMU 41	Red Water Ash Landfill	1992		×		×							×	×				×	×	×																					

Table A.2a, continued

Area of Groundwater Sampling	Description	Date of Sampling	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Vanadium	Zinc	Chloride	Fluoride	Nitrate	Sulfate	Cyanide	Perchlorate	2-Amino-4,6-dinitrotoluene	4-Amino-2,6-dinitrotoluene	Aminodinitrotoluene	1,3-Dinitrobenzene	2,4-Dinitrotoluene	2,6-Dinitrotoluene	Dinitrotoluene	HMX	Nitrobenzene	o- (2-) Nitrotoluene	p- (4-) Nitrotoluene	RDX	Tetryl	1,3,5-Trinitrobenzene	2,4,6-Trinitrotoluene
Units Studied, Horseshoe Area of MMA, Western																																									
SWMU 31	Coal Ash Settling Lagoons	1998, 2008																																								
SWMU 57	Former Acid Settling Pond	2008	×	×	×	×		×	×	×	×	×	×	×		×			×	×						×																
SWMU 57	Former Acid Settling Pond	2010		×	×				×					×																												
Units Studied, Horseshoe Area of MMA, Central																																									
SWMU 39	Incinerator Wastewater Ponds	1993	×	×	×	×			×		×	×	×	×		×			×	×																						
SWMU 39	Incinerator Wastewater Ponds	2003-2007			×	×			×			×	×	×		×					×	×	×	×																		
SWMU 32	Inert Waste Landfill	1992				×						×		×																												
SWMU 26	Fly Ash Landfill	1992				×					×		×	×	×																												
Units Studied, Horseshoe Area of MMA, Eastern																																									
SWMUs 28, 51 & 52	Sanitary landfill; TNT Neutralization Sludge Disposal; Closed Sanitary Landfill	1992	×		×	×						×	×	×						×												×									
HWMU 16	Closed Hazardous Waste Landfill	2003-2012				×	×	×	×	×	×		×		×	×		×		×																						
HWMU 16	Closed Hazardous Waste Landfill	1982-1984				×			×			×	×	×							×	×	×	×									×									
SWMUs 27 &29	Calcium Sulfate Landfill & Fly Ash Landfill #2	-												×							×		×	×																		
SWMU 27, 53, 29	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1985, 1991, 1992							×			×	×	×	×								×																		
SWMUs 27, 29 & 53	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1993				×								×																											
SWMU 50	Calcium Sulfate Disposal	2007	×		×	×	×	×	×	×	×	×	×	×	×	×			×	×						×																
SWMU 51 Vicinity	TNT Neutralization Sludge Disposal and Nearby Units	2006-2007	×	×	×	×	×		×	×	×	×	×	×		×	×		×	×						×																
SWMU 74	Inert Landfill	1991				×								×																												
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1992	×		×	×						×		×				×		×														×								×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1995, 1997	×	×	×	×	×		×		×	×	×	×		×			×	×														×								
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1999	×			×					×	×		×						×						×	×							×								×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2003-2004				×			×	×		×		×		×	×		×	×						×	×	×			×			×				×		×	×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2007																								×	×	×	×		×	×	×	×	×	×	×	×		×	×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2002																								×							×					×			×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2004																								×							×					×			×
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2011-2012																								×							×					×			×
HWMU/ SWMU 13	Open Burning Ground	1991			×	×			×				×	×									×															×			
HWMU/ SWMU 13	Open Burning Ground	2003-2014				×			×							×	×			×						×															

× = detected; did not consider calcium, magnesium, potassium, sodium, or tentatively identified compounds.
Highlighted × = detected above drinking water CVs (see Table A.2b), or no CV available.

Table A.2b. Comparison Values and Cancer Screening Values for Contaminants Detected in Radford Army Ammunition Plant Groundwater Sampling - Metals, Inorganics, and Explosives-Related Compounds

Compound	Highest Detected Concentration in micrograms per Liter (µg/L)	Number of Studies with Detections Above CV (CREG) / # Reporting Detections	Drinking Water Comparison Value* (CV) in µg/L	CV Source (see end of table for abbreviations)	Cancer Risk Evaluation Guide in µg/L
Aluminum	93100	9 / 18	10000	EMEG	-
Antimony	110	8 / 13	4	RMEG	-
Arsenic	2670	12 (17) / 18	3	EMEG	0.023
Barium	N/A	0 / 40	2000	EMEG	-
Beryllium	20	3 / 11	20/4	EMEG/MCL	-
Cadmium	14.7	3 / 10	1	EMEG	-
Chromium	626	19 / 31	9	EMEG for hexavalent chromium	-
Cobalt	N/A	0 / 19	100	iEMEG	-
Copper	124	2 / 22	100	iEMEG	-
Iron	129000	11 / 30	11000	RSL	-
Lead	558	9 / 30	15	AL	-
Manganese	30500	17 / 37	300	LTHA	-
Mercury	311800	3 / 11	1	RMEG for methylmercury	-
Nickel	222	3 / 22	100	LTHA	-
Selenium	N/A	0 / 12	50	EMEG	-
Silver	N/A	0 / 9	50	RMEG	-
Vanadium	201	4 / 18	100	iEMEG	-
Zinc	N/A	0 / 27	2000	LTHA	-
Chloride	N/A	0 / 4	250000	SDWS	-
Fluoride	35000	1 / 4	2000	SDWS	-
Nitrate	301000	9 / 13	10000	MCL	-
Sulfate	2652000	6 / 9	250000	SDWS	-
Cyanide	N/A	0 / 1	6	RMEG	-
Perchlorate	143	7 / 20	7	EMEG	-
2-Amino-4,6-dinitrotoluene	N/A	0 / 4	30	RSL	-
4-Amino-2,6-dinitrotoluene	N/A	0 / 3	30	RSL	-
Aminodinitrotoluene	N/A	0 / 1	30	RSL	-
1,3-Dinitrobenzene	N/A	0 / 1	1	RMEG	-
2,4-Dinitrotoluene	3	0 (5) / 5	10	EMEG	0.051
2,6-Dinitrotoluene	32	0 (6) / 6	40	iEMEG	0.051
Dinitrotoluene mixture	1.146	N/A (1) / 3	none	-	0.051
HMX (cyclotetramethylene tetranitramine)	N/A	0 / 10	400	LTHA	-
Nitrobenzene	N/A	0 / 3	20	RMEG	-
o-Nitrotoluene (2-Nitrotoluene)	0.82	1 / 1	0.27	RSL	-
p-Nitrotoluene (4-Nitrotoluene)	N/A	0 / 1	3.7	RSL	-
RDX (cyclonite)	35	2 (6) / 7	30	RMEG	0.32
Tetryl (Trinitrophenylmethylnitramine)	N/A	0 / 2	61	RSL	-
1,3,5-Trinitrobenzene	N/A	0 / 2	300	RMEG	-
2,4,6-Trinitrotoluene	160	5 (7) / 7	5	RMEG	1.2

Abbreviations Used:

EMEG = environmental media evaluation guide MCL = maximum contaminant level RMEG = reference media evaluation guide SDWS = secondary drinking water standard
AL = action level RSL = regional screening level LTHA = lifetime health advisory CREG = cancer risk evaluation guide

Prefix i indicates CV is for intermediate duration exposures(<1 yr) rather than chronic. Highlighted **BOLD** = Contaminants detected at values higher than the lowest CV, or the CREG.

Table A.3a. Detections of Pesticide and Volatile Contaminants in Groundwater at Specific Units at Radford Army Ammunition Plant

			Pesticides							Volatile Compounds																																
Area of Groundwater Sampling	**Description**	**Date of Sampling**	alpha-BHC	beta-BHC	delta-BHC	Chlordane	Endosulfan	gamma-BHC	Heptachlor epoxide	Acetone	Benzene	Bromodichloromethane	Carbon Disulfide	Carbon Tetrachloride	Chloroethane	Chloroform	Chloromethane	1,3-Dichlorobenzene	Dichloro-difluoromethane	1,1-Dichloroethane	1,1-Dichloroethylene	1,2-Dichloroethane	1,2-Dichloroethylene	Dichloro-fluoromethane	1,2-Dichloropropane	Diethyl ether	Dimethyl ether	Ethylbenzene	Isopropanol	Methylene chloride	4-Methyl-2-pentanone (MIBK)	Tetrachloroethylene	Tetrahydrofuran	Toluene	1,1,1-Trichloroethane	Trichloroethylene	Trichloro-fluoromethane
Units Studied, Southern Area of MMA, Along River, From West to East																																									
SWMU 46	Waste Propellant Disposal Area (PCE and daughter products only)	2006																																							
HWMU 7	Former Surface Impoundment	1985																																							
HWMU 7	Former Surface Impoundment	2008-2012														×																										
SWMU 37	Calcium Sulfate Drying Bed	2008	×	×	×	×	×	×	×	×						×		×																	×						
SWMU 9	C-line nitrocellulose wastewater	1980																																								
SWMU 38 and Area Q	Calcium Sulfate Drying Bed & Abandoned Lagoon Used for Calcium Sulfate Disposal	2008		×			×									×	×																	×						
SWMU 45	Sanitary Landfill	1991											×																						×						
SWMU 45	Sanitary Landfill	2008														×																			×						
Area F	Drum/ Container Storage Area (Chromium only metal tested)	2006																																								
Area P	Scrap Metal Salvage Yard	2007														×																					×					
HWMU 10	Former Equalization Basin for Biological Treatment Plant	1990																																								
HWMU 10	Former Equalization Basin for Biological Treatment Plant	2008-2012								×						×															×										
HWMU 10 & SWMU 35	Former Equalization Basin for Biol.Treatment Plant & Calcium Sulfate Drying Bed	1991											×			×	×						×												×						
SWMU 35	Calcium Sulfate Drying Bed (chromium and lead only metals tested)	1993																																								
SWMU 35	Calcium Sulfate Drying Bed	2008				×										×																				×						
SWMU 8	AB-Line acidic wastewater	1980																																								
SWMU 43	Sanitary Landfill	1991									×		×												×																	
Units Studied, Southern Area of MMA, Away (>500 ft) From River, Generally From West to East																																									
Oleum Plant	Former Oleum Plant	2007		×		×			×					×		×					×															×	×		×		×	
SWMU 6	Acidic Wastewater Lagoon	1992																																								
SWMU 40	Sanitary Landfill Nitroglycerine Area	1995																																								
SWMU 40	Sanitary Landfill Nitroglycerine Area	2007						×		×						×																										
SWMU 40	Sanitary Landfill Nitroglycerine Area	2011-2012														×																										
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	1995																																								
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	2007				×		×																																		
FLFA	Former Lead Furnace Area	2007						×								×																					×		×			
HWMU 5	Former Surface Impoundment	1983-1984																																								
HWMU 5	Former Surface Impoundment	1996-2012								×						×			×								×														×	
HWMU 5	Former Surface Impoundment	2009																																								
Area O	Underground Fuel Oil Spill	1992									×		×			×	×											×		×					×						
Area O	Underground Fuel Oil Spill	1993																																								
Area O	Underground Fuel Oil Spill	2007														×																										
HWMU 4	Acidic Wastewater Lagoon	1984																																								
SWMU 41	Red Water Ash Landfill	1992																																								

Table A.3a, continued

			Pesticides							Volatile Compounds																											
Area of Groundwater Sampling	**Description**	**Date of Sampling**	alpha-BHC	beta-BHC	delta-BHC	Chlordane	Endosulfan	gamma-BHC	Heptachlor epoxide	Acetone	Benzene	Bromodichloromethane	Carbon Disulfide	Carbon Tetrachloride	Chloroethane	Chloroform	Chloromethane	1,3-Dichlorobenzene	Dichloro-difluoromethane	1,1-Dichloroethane	1,1-Dichloroethylene	1,2-Dichloroethane	1,2-Dichloroethylene	Dichloro-fluoromethane	1,2-Dichloropropane	Diethyl ether	Dimethyl ether	Ethylbenzene	Isopropanol	Methylene chloride	4-Methyl-2-pentanone (MIBK)	Tetrachloroethylene	Tetrahydrofuran	Toluene	1,1,1-Trichloroethane	Trichloroethylene	Trichloro-fluoromethane
Units Studied, Horseshoe Area of MMA, Western																																					
SWMU 31	Coal Ash Settling Lagoons	1998, 2008																																			
SWMU 57	Former Acid Settling Pond	2008					×			×						×		×																×			
SWMU 57	Former Acid Settling Pond	2010														×														×							
Units Studied, Horseshoe Area of MMA, Central																																					
SWMU 39	Incinerator Wastewater Ponds	1993																																			
SWMU 39	Incinerator Wastewater Ponds	2003-2007																																			
SWMU 32	Inert Waste Landfill	1992																																			
SWMU 26	Fly Ash Landfill	1992											×								×													×			×
Units Studied, Horseshoe Area of MMA, Eastern																																					
SWMUs 28, 51 & 52	Sanitary landfill; TNT Neutralization Sludge Disposal; Closed Sanitary Landfill	1992											×							×										×				×	×		×
HWMU 16	Closed Hazardous Waste Landfill	2003-2012									×				🟧×				×	🟧×	×						🟧×			×		×	×		×	×	
HWMU 16	Closed Hazardous Waste Landfill	1982-1984										🟧×				×								×						×							×
SWMUs 27 &29	Calcium Sulfate Landfill & Fly Ash Landfill #2	-																																			
SWMU 27, 53, 29	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1985, 1991, 1992																																			
SWMUs 27, 29 & 53	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1993																																			
SWMU 50	Calcium Sulfate Disposal	2007												×																		×				×	
SWMU 51 Vicinity	TNT Neutralization Sludge Disposal and Nearby Units	2006-2007				🟧×			🟧×					🟧×	🟧×					🟧×	🟧×		×												×	🟧×	
SWMU 74	Inert Landfill	1991																																			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1992											×																								
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1995, 1997								×																				×							
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1999											×																	×		×		×			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2003-2004																																			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2007																																			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2002																																			
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2004																																			
HWMU/ SWMU 13	Open Burning Ground	1991											×	🟧×		×						🟧×			×											🟧×	
HWMU/ SWMU 13	Open Burning Ground	2003-2012												🟧×		×				×															×	🟧×	

× = detected
Highlighted × = detected above drinking water CVs (see Table A.3b), or no CV available.

Table A.3b. Comparison Values and Cancer Screening Values for Contaminants Detected in Radford Army Ammunition Plant Groundwater Sampling - Pesticides and Volatiles

	Compound	Highest Detected Concentration Above CV in micrograms per Liter (µg/L)	Number of Studies with Detections Above CV (CREG) / # Reporting Detections	Drinking Water Comparison Value* (CV) in µg/L	CV Source (see end of table for abbreviations)	Cancer Risk Evaluation Guide in µg/L
Pesticides	**alpha-BHC (Benzene hexachloride)**	0.49	0 (1) / 1	80	EMEG	0.0056
	beta-BHC (Benzene hexachloride)	N/A	0 / 3	6	iEMEG	0.019
	delta-BHC (benzene hexachloride)	N/A	0 / 1	80	EMEG for alpha-BHC	0.0056
	Chlordane	0.29	0 (2) / 5	6	EMEG	0.1
	Endosulfan	N/A	0 / 3	20	EMEG	-
	gamma-BHC (Lindane)	N/A	0 / 4	0.1	iEMEG	-
	Heptachlor epoxide	0.15	1 (3) / 3	0.13	RMEG	0.0038
Volatile Compounds	**Acetone**	18000	1 / 6	9000	RMEG	-
	Benzene	2.18	0 (1) / 3	5	EMEG	0.64
	Bromodichloromethane	3	0 (1) / 1	200	EMEG	0.56
	Carbon Disulfide	N/A	0 / 9	1000	RMEG	-
	Carbon Tetrachloride	94.6	1 (4) / 5	40	RMEG	0.5
	Chloroethane (Ethyl chloride)	5.2	N/A / 2	none	-	-
	Chloroform	N/A	0 / 20	100	EMEG	-
	Chloromethane	N/A	0 / 3	190	RSL	-
	1,3-Dichlorobenzene	N/A	0 / 2	200	iEMEG	-
	Dichlorodifluoromethane	N/A	0 / 2	2000	RMEG	-
	1,1-Dichloroethane	8.5	2 / 4	2.4	RSL	-
	1,1-Dichloroethylene	N/A	0 / 4	90/7	EMEG/MCL	-
	1,2-Dichloroethane	1.51	0 (2) / 2	5	MCL	0.38
	1,2-Dichloroethylene	N/A	0 / 2	20	RMEG	-
	Dichlorofluoromethane	N/A	0 / 1	2000	RMEG for dichlorodifluoromethane	-
	1,2-Dichloropropane	N/A	0 / 1	900/5	EMEG/MCL	-
	Diethyl ether (aka ethyl ether)	N/A	0 / 1	2000	RMEG	-
	Dimethyl ether (methoxymethane)	7.7	N/A / 1	none	-	-
	Ethylbenzene	N/A	0 / 1	700	LTHA	-
	Isopropanol (2-Propanol)	45000	N/A / 1	none	-	-
	Methylene chloride	N/A	0 / 7	600	EMEG	18
	4-Methyl-2-pentanone (MIBK)	N/A	0 / 1	1000	RSL	-
	Tetrachloroethylene	N/A	0 / 7	5	MCL	17
	Tetrahydrofuran	N/A	0 / 1	9000	RMEG	-
	Toluene	N/A	0 / 14	200	iEMEG	-
	1,1,1-Trichloroethane	N/A	0 / 4	200	MCL	-
	Trichloroethylene	26	3 (4) / 7	5	MCL	0.76
	Trichlorofluoromethane	N/A	0 / 3	2000	LTHA	-

Abbreviations Used:

EMEG = environmental media evaluation guide MCL = maximum contaminant level RMEG = reference media evaluation guide SDWS = secondary drinking water standard
AL = action level RSL = regional screening level LTHA = lifetime health advisory CREG = cancer risk evaluation guide

Prefix i indicates CV is for intermediate duration exposures(<1 yr) rather than chronic. Highlighted **BOLD** = Contaminants detected at values higher than the lowest CV, or the CREG.

Table A.4a. Detections of Semi-Volatile and Dioxin/Furan Contaminants in Groundwater at Specific Units at Radford Army Ammunition Plant

			Semi-Volatile Compounds																																			Dioxins and Furans								
Area of Groundwater Sampling	**Description**	**Date of Sampling**	1-Methylnaphthalene	2-Chlorophenol	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Acetophenone	Anthracene	Benzaldehyde	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	1,1'-Biphenyl	Bis(2-chloroethoxy) methane	Bis(2-chloroethyl) ether	Bis(2-ethylhexyl) Phthalate	Butyl benzyl phthalate	Carbazole	Chrysene	Di-n-butyl phthalate	Di-n-octylphthalate	Dibenzofuran	Diethyl phthalate	Dimethyl phthalate	Fluoranthene	Fluorene	Hexachloroethane	Indeno(1,2,3-c,d)pyrene	Isophorone	Naphthalene	o- (2-) Nitroaniline	p- (4-) Nitroaniline	n-Nitrosodiphenylamine	Phenanthrene	Phenol	Pyrene	Heptachloro-dibenzodioxin	Heptachloro-dibenzofuran	Hexachloro-dibenzodioxin	Hexachloro-dibenzofuran	Octachloro-dibenzodioxin	Octachloro-dibenzofuran	Pentachloro-dibenzofuran	Pentachloro-dibenzodioxin	Tetrachloro-dibenzofuran
Units Studied, Southern Area of MMA, Along River, From West to East																																																
SWMU 46	Waste Propellant Disposal Area (PCE and daughter products only)	2006																																												
HWMU 7	Former Surface Impoundment	1985																																												
HWMU 7	Former Surface Impoundment	2008-2012																																												
SWMU 37	Calcium Sulfate Drying Bed	2008																																												
SWMU 9	C-line nitrocellulose wastewater	1980																																												
SWMU 38 and Area Q	Calcium Sulfate Drying Bed & Abandoned Lagoon Used for Calcium Sulfate Disposal	2008																																												
SWMU 45	Sanitary Landfill	1991															×																													
SWMU 45	Sanitary Landfill	2008		×	×	×	×	×			×					×	×		×	×		×	×	×	×	×		×		×			×				×	×										
Area F	Drum/ Container Storage Area (Chromium only metal tested)	2006																																												
Area P	Scrap Metal Salvage Yard	2007																																												
HWMU 10	Former Equalization Basin for Biological Treatment Plant	1990																				×																								
HWMU 10	Former Equalization Basin for Biological Treatment Plant	2008-2012																																												
HWMU 10 & SWMU 35	Former Equalization Basin for Biol.Treatment Plant & Calcium Sulfate Drying Bed	1991																×																												
SWMU 35	Calcium Sulfate Drying Bed (chromium and lead only metals tested)	1993																																												
SWMU 35	Calcium Sulfate Drying Bed	2008							×										×	×			×					×				×					×											
SWMU 8	AB-Line acidic wastewater	1980																																												
SWMU 43	Sanitary Landfill	1991																																												
Units Studied, Southern Area of MMA, Away (>500 ft) From River, Generally From West to East																																																
Oleum Plant	Former Oleum Plant	2007																×					×									×														
SWMU 6	Acidic Wastewater Lagoon	1992																																												
SWMU 40	Sanitary Landfill Nitroglycerine Area	1995																																												
SWMU 40	Sanitary Landfill Nitroglycerine Area	2007			×											×				×						×							×														
SWMU 40	Sanitary Landfill Nitroglycerine Area	2011-2012									×	×	×	×	×							×						×			×						×		×	×				×				
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	1995																																												
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	2007																		×						×	×																				
FLFA	Former Lead Furnace Area	2007			×															×						×							×									×		×		×		
HWMU 5	Former Surface Impoundment	1983-1984																																												
HWMU 5	Former Surface Impoundment	1996-2012																																×	×													
HWMU 5	Former Surface Impoundment	2009																																												
Area O	Underground Fuel Oil Spill	1992			×	×													×									×	×							×	×		×									
Area O	Underground Fuel Oil Spill	1993			×	×																			×				×				×				×											
Area O	Underground Fuel Oil Spill	2007	×		×	×	×												×		×								×				×				×		×									
HWMU 4	Acidic Wastewater Lagoon	1984																																												
SWMU 41	Red Water Ash Landfill	1992																×																												

Table A.4a, continued

		Semi-Volatile Compounds																																		Dioxins and Furans								
Area of Groundwater Sampling	**Description**	**Date of Sampling**	1-Methylnaphthalene	2-Chlorophenol	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Acetophenone	Anthracene	Benzaldehyde	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene			1,1'-Biphenyl	Bis(2-chloroethoxy) methane	Bis(2-chloroethyl) ether	Bis(2-ethylhexyl) Phthalate	Butyl benzyl phthalate	Carbazole	Chrysene	Di-n-butyl phthalate	Di-n-octylphthalate	Dibenzofuran	Diethyl phthalate	Dimethyl phthalate	Fluoranthene	Fluorene	Hexachloroethane		Isophorone	Naphthalene	o- (2-) Nitroaniline	p- (4-) Nitroaniline	n-Nitrosodiphenylamine	Phenanthrene	Phenol	Pyrene	Heptachloro-dibenzodioxin	Heptachloro-dibenzofuran	Hexachloro-dibenzodioxin	Hexachloro-dibenzofuran	Octachloro-dibenzodioxin	Octachloro-dibenzofuran	Pentachloro-dibenzofuran	Pentachloro-dibenzodioxin	Tetrachloro-dibenzofuran
Units Studied, Horseshoe Area of MMA, Western																																												
SWMU 31	Coal Ash Settling Lagoons	1998, 2008									×	×	×																																
SWMU 57	Former Acid Settling Pond	2008			×			×		×										×			×			×						×	×											
SWMU 57	Former Acid Settling Pond	2010																																											
Units Studied, Horseshoe Area of MMA, Central																																												
SWMU 39	Incinerator Wastewater Ponds	1993																																											
SWMU 39	Incinerator Wastewater Ponds	2003-2007																																											
SWMU 32	Inert Waste Landfill	1992																																											
SWMU 26	Fly Ash Landfill	1992																	×																											
Units Studied, Horseshoe Area of MMA, Eastern																																												
SWMUs 28, 51 & 52	Sanitary landfill; TNT Neutralization Sludge Disposal; Closed Sanitary Landfill	1992																	×																										
HWMU 16	Closed Hazardous Waste Landfill	2003-2012																																											
HWMU 16	Closed Hazardous Waste Landfill	1982-1984																								×																			
SWMUs 27 &29	Calcium Sulfate Landfill & Fly Ash Landfill #2	-																																											
SWMU 27, 53, 29	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1985, 1991, 1992																																											
SWMUs 27, 29 & 53	Calcium Sulfate Landfill; Activated Carbon Disposal; Fly Ash Landfill #2	1993																																											
SWMU 50	Calcium Sulfate Disposal	2007																	×																											
SWMU 51 Vicinity	TNT Neutralization Sludge Disposal and Nearby Units	2006-2007																																											
SWMU 74	Inert Landfill	1991																																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1992																																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1995, 1997																	×																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	1999																	×																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2003-2004																																												
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2007																																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2002																																											
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	2004																																											
HWMU/ SWMU 13	Open Burning Ground	1991																																											
HWMU/ SWMU 13	Open Burning Ground	2003-2012																																											

× = detected

Highlighted × = detected above drinking water CVs (see Table A.4b), or no CV available.

Table A.4b. Comparison Values and Cancer Screening Values for Contaminants Detected in Radford Army Ammunition Plant Groundwater Sampling - Semi-Volatile and Dioxin/Furan Compounds

	Compound	Highest Detected Concentration Above CV in micrograms per Liter (µg/L)	Number of Studies with Detections Above CV (CREG) / # Reporting Detections	Drinking Water Comparison Value* (CV) in µg/L	CV Source (see end of table for abbreviations)	Cancer Risk Evaluation Guide in µg/L
Semi-volatile Compounds	1-Methylnaphthalene	N/A	0 / 1	700	EMEG	-
	2-Chlorophenol	N/A	0 / 1	50	RMEG	-
	2-Methylnaphthalene	180	0 / 7	400/40	EMEG/RMEG	-
	Acenaphthene	N/A	0 / 4	600	RMEG	-
	Acenaphthylene	18.2	N/A / 2	none	-	-
	Acetophenone	N/A	0 / 2	1000	RMEG	-
	Anthracene	N/A	0 / 1	3000	RMEG	-
	Benzaldehyde	N/A	0 / 1	1000	RMEG	-
	Benzo(a)anthracene	0.211	2 / 3	0.029	RSL	-
	Benzo(a)pyrene	0.0793	0 (2) / 2	0.2	MCL	0.0048
	Benzo(b)fluoranthene	0.261	1 / 2	0.029	RSL	-
	Benzo(g,h,i)perylene	0.0475	N/A / 1	none	-	-
	Benzo(k)fluoranthene	0.17	0 / 1	0.29	RSL	-
	1,1-Biphenyl	N/A	0 / 2	500	RMEG	-
	Bis(2-chloroethoxy)methane	N/A	0 / 1	46	RSL	-
	Bis(2-chloroethyl)ether	3.39	N/A (1) / 1	none	-	0.032
	Bis(2-ethylhexyl)phthalate	23.1	0 (9) / 12	600	EMEG	2.5
	Butyl benzyl phthalate	N/A	0 / 6	2000	RMEG	-
	Carbazole	1.7	N/A / 1	none	-	-
	Chrysene	N/A	0 / 2	2.9	RSL	-
	Di-n-butyl phthalate	N/A	0 / 4	1000	RMEG	-
	Di-n-octylphthalate	N/A	0 / 2	4000	iEMEG	-
	Dibenzofuran	N/A	0 / 2	5.8	RSL	-
	Diethyl phthalate	N/A	0 / 6	8000	RMEG	-
	Dimethyl phthalate	N/A	0 / 1	1000	RMEG	-
	Fluoranthene	N/A	0 / 4	400	RMEG	-
	Fluorene	N/A	0 / 3	400	RMEG	-
	Hexachloroethane	N/A	0 / 1	7	RMEG	0.88
	Indeno(1,2,3-cd)pyrene	0.0391	1 / 1	0.029	RSL	-
	Isophorone	N/A	0 / 2	2000	EMEG	37
	Naphthalene	N/A	0 / 7	200	RMEG	-
	o-Nitroaniline (2-Nitroaniline)	N/A	0 / 1	150	RSL	-
	p-Nitroaniline (4-Nitroaniline)	N/A	0 / 1	3.3	RSL	-
	n-Nitrosodiphenylamine	46	1 / 1	10	RSL	-
	Phenanthrene	163	N/A / 6	none	-	-
	Phenol	N/A	0 / 1	3000	RMEG	-
	Pyrene	N/A	0 / 3	300	RMEG	-
Dioxins and Furans	**Octachlorodibenzodioxin**	1.1	2 / 4	0.033	EMEG**	-
	Octachlorodibenzofuran	0.0513	1 / 2	0.033	EMEG**	-
	Heptachlorodibenzodioxin	0.0802	2 / 3	0.001	EMEG**	-
	Heptachlorodibenzofuran	0.0238	2 / 2	0.001	EMEG**	-
	Hexachlorodibenzodioxin	0.0197	1 / 3	0.0001	EMEG**	-
	Hexachlorodibenzofuran	0.0102	2 / 2	0.0001	EMEG**	-
	Pentachlorodibenzodioxin	0.003	1 / 2	0.00001	EMEG**	-
	Pentachlorodibenzofuran	0.0067	1 / 1	0.00003	EMEG**	-
	Tetrachlorodibenzofuran	0.0051	2 / 2	0.0001	EMEG**	-

Abbreviations Used:

EMEG = environmental media evaluation guide MCL = maximum contaminant level RMEG = reference media evaluation guide SDWS = secondary drinking water standard

AL = action level RSL = regional screening level LTHA = lifetime health advisory CREG = cancer risk evaluation guide

Prefix i indicates CV is for intermediate duration exposures(<1 yr) rather than chronic. **BOLD** = Contaminants detected at values higher than the lowest CV, or the CREG.

**EMEG for dioxins and furans calculated using EMEG for 2,3,7,8-tetrachlorodibenzodioxin and World Health Organization Toxicity Equivalence Factors.

Table A.5. Geology and Groundwater Conditions at Units at Radford Army Ammunition Plant

South Area, Units Along River, From West to East		
Area	**Description**	**Groundwater at Site**
SWMU 46	Waste Propellant Disposal Area	Unconfined aquifer near the soil/bedrock interface and in underlying bedrock; GW flow is north or northwest towards the New River. [57]
HWMU 7	Former Surface Impoundment	Unconfined aquifer in unconsolidated sediments and underlying carbonate bedrock; GW flow is west toward the New River and northeast and southwest toward unnamed drainages that flow into the New River north and south of the unit. [59-63]
SWMU 37	Calcium Sulfate Drying Bed	Unconfined aquifer in unconsolidated river sediments and underlying fractured bedrock above competent bedrock; GW flow is radial out from the bed. [64]
SWMU 9	C-line nitrocellulose wastewater	Unconfined aquifer generally along surface of moderately fractured bedrock underlying unconsolidated sediments; GW flow is presumed toward the New River [68]
SWMU 38	Calcium Sulfate Drying Bed	Unconfined aquifer in unconsolidated river sediments and underlying fractured bedrock above competent bedrock; GW flow is north and northeast. [64]
Area Q	Abandoned Lagoon Used for Calcium Sulfate Disposal	Unconfined aquifer in unconsolidated river sediments and underlying fractured bedrock above competent bedrock; GW flow is north and northeast. [64]
SWMU 45	Sanitary Landfill	Unconfined aquifer in lower portion unconsolidated sediments; bedrock greater than 36 ft bgs; GW flow is towards the east and northeast [65]
Area F	Drum/ Container Storage Area	Unconfined aquifer in the lower portion of unconsolidated soil and underlying bedrock; GW flow is north toward the New River. [57]
Area P	Scrap Metal Salvage Yard	Unconfined aquifer in unconsolidated river sediments, GW flow presumed to be north to the New River on basis of similar sites [66]
SWMU 10	Former Equalization Basin for Biological Treatment Plant	Unconfined aquifer in unconsolidated sediments and underlying limestone bedrock; GW flow is north toward the New River [59-63]
SWMU 35	Calcium Sulfate Drying Bed	Unconfined aquifer in lower portion of unconsolidated soil and underlying bedrock; GW flow is north toward the New River [64]
SWMU 8	AB-Line acidic wastewater	Unconfined aquifer in unconsolidated deposits and underlying fractured bedrock; GW flow is north toward the New River [68]
SWMU 36	Calcium Sulfate Drying Bed	Unconfined aquifer in unconsolidated deposits and underlying fractured bedrock; GW flow is north toward the New River to east toward Stroubles Creek [68]
SWMU 43	Sanitary Landfill	Unconfined aquifer in unconsolidated river sediments and underlying fractured bedrock; GW flow is north toward the New River [68]
South Area, Units Away (>500 ft) From River, Generally From West to East		
Area	**Description**	**Groundwater at Site**
Oleum Plant	Former Oleum Plant	Only general information available in [70]
SWMU 6	Acidic Wastewater Lagoon	In area of karst terrain; lagoon suspected to be built in a collapsed sinkhole. [68]
SWMU 40	Sanitary Landfill Nitroglycerine Area	Thin layer of silty clay over bedrock with intense fracturing and abundant clayey zones; GW controlled by karst conditions; GW flow rapid and likely westward toward New River [68, 49]

SWMU 71	Flash Burn Parts Area	GW conditions inferred from contiguous SWMU 40 (karst conditions) [68]
SWMU 17	Air Curtain Destructor, Contaminated Waste Burning	Thin layer of silty clay over fractured bedrock; fractures often filled with clay; voids also present; GW controlled by karst conditions; GW flow rapid and likely westward toward New River [49,50] Currently, impermeable layer prevents water from reaching groundwater and stormwater is controlled [29]
SWMU 76	Waste Oil Underground Storage Tanks (2)	Thin layer of silty clay over fractured bedrock with voids; GW controlled by karst conditions [97]
FLFA	Former Lead Furnace Area	Fill materials and overburden over weathered and fractured bedrock; karst conditions [98]
HWMU 5	Former Surface Impoundment	Unconfined aquifer in unconsolidated sediments and underlying bedrock; GW flow is northeast [59-63]
Area A	Nitrocellulose Line A Rainwater Ditch	Unconfined aquifer more than 20 feet below ground surface (in overburden) [22]
Area O	Underground Fuel Oil Spill	Unconfined aquifer in overburden and bedrock; GW flow is northeast toward discharge seep along scarp to the north [78]
HWMU 4	Acidic Wastewater Lagoon	Based on nearby sites (5 and 41), unconfined aquifer in weathered bedrock.
SWMU 75	Waste Oil Underground Storage Tank	Based on nearby Area O, unconfined aquifer in overburden above bedrock; GW flow is toward northeast [97]
SWMU 41	Red Water Ash Landfill	Unconfined aquifer in weathered bedrock; GW flow is northeast toward Stroubles Creek [68]
Horseshoe Area, Western		
Area	**Description**	**Groundwater at Site**
SWMU 31	Coal Ash Settling Lagoons	Unconfined aquifer in unconsolidated river sediments and underlying bedrock; GW flow is northwest. [99]
SWMU 68	Former (1958-1978) Chromic Acid Treatment Plant	Unconfined aquifer in the lower portion of unconsolidated soil and underlying bedrock; GW flow is northwest toward the New River. [57]
SWMU 69	Former Settling Pond by Chromic Acid Treatment Plant	Unconfined aquifer in unconsolidated soil and underlying bedrock; GW flow is northwest toward the New River. [57]
SWMU 57	Former Acid Settling Pond	Unconfined aquifer in the lower portion of unconsolidated river deposits and underlying bedrock; GW flow is north or northwest toward the base of the terrace and the New River. [57]
Building 4343	Former Cadmium Plating Facility	Unconsolidated river sediments and underlying bedrock; groundwater not within 6 feet of ground surface [23]
Horseshoe Area, Central		
Area	**Description**	**Groundwater at Site**
SWMU 39	Incinerator Wastewater Ponds	Subsurface conditions inferred from other areas [68]
SWMU 58	Rubble Pile	GW conditions expected to be similar to nearby SWMU 26 and 32 (karst features) [68]
SWMU 32	Inert Waste Landfill	Some GW in bedrock; some areas showed karst features; inferred GW flow rapid and north toward New River [68]

SWMU 26	Fly Ash Landfill	Some GW in bedrock; karst features in bedrock; inferred GW flow rapid [68]
Horseshoe Area, Eastern		
Area	**Description**	**Groundwater at Site**
SWMU 50	Calcium Sulfate Disposal	Unconfined aquifer in bedrock; GW flow is south toward the New River [98]
SWMU 48	Oily Wastewater Disposal	Unconfined aquifer in bedrock; GW flow is south toward the New River [98]
SWMU 59	Bottom Ash Pile	Unconfined aquifer in bedrock; GW flow is south toward the New River [98]
SWMU 49	Red Water Ash Disposal	Unconfined aquifer in bedrock; GW flow is south toward the New River [98]
SWMU 51	TNT Neutralization Sludge Disposal	Unconfined aquifer near overburden/ bedrock interface; GW flow is outward from SWMU 51/28/52 area [77]
SWMU 30	Asbestos Disposal Trench	Unconfined aquifer near overburden/ bedrock interface; GW flow is outward from SWMU 51/28/52 area [77]
SWMU 28	Sanitary Landfill	Unconfined aquifer near overburden/ bedrock interface; GW flow is outward from SWMU 51/28/52 area [77]
HWMU 16	Closed Hazardous Waste Landfill	GW flow is generally to the northeast [59-63]
SWMU 52	Closed Sanitary Landfill	Unconfined aquifer near overburden/ bedrock interface; GW flow is outward from SWMU 51/28/52 area [77]
SWMU 27	Calcium Sulfate Landfill	Unconfined aquifer near the soil/bedrock interface and in underlying fractured bedrock above competent bedrock; GW flow is south and east towards the New River. [68]
SWMU 53	Activated Carbon Disposal	Unconfined aquifer near the soil/bedrock interface and in underlying fractured bedrock above competent bedrock; GW flow is south and east towards the New River. [68]
SWMU 29	Fly Ash Landfill #2	Unconfined aquifer near the soil/bedrock interface and in underlying fractured bedrock above competent bedrock; GW flow is south and east towards the New River. [68]
SWMU 74	Inert Landfill	Unconfined aquifer near the overburden soil bedrock interface and in underlying bedrock; GW flow is east toward the New River. [68]
HWMU/ SWMU 13	Open Burning Ground	Unconfined aquifer in unconsolidated river sediment and underlying bedrock; GW flow is south towards the New River. [57]
SWMU 54	Disposal Area for Ash from Burning of Waste Propellants	Unconfined aquifer in unconsolidated sediments and weathered bedrock layer over competent bedrock; GW flow eastward toward the New River. [68,90]

Appendix B. Explanation of Comparison Values

In evaluating the site data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are health-based contaminant concentrations found in a specific media (air, soil, or water) and are used to screen contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone might inhale or ingest each day.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and noncancer health effects. Noncancer levels are based on valid toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children and adults are exposed every day. Cancer levels are based on a one-in-a-million excess cancer risk for exposure to contaminated soil or drinking contaminated water every day for 70 years. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

CVs used in preparing this document are listed below:

Action Levels (ALs) are contaminant concentrations which, if exceeded, trigger treatment or other requirements which a water system must follow. For example, it is the level of lead or copper which, if exceeded in over 10% of the homes tested, triggers treatment for corrosion control.

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA cancer slope factors.

Environmental Media Evaluation Guides (EMEGs) are estimated contaminant concentrations in a media where noncancer health effects are unlikely. EMEGs are derived from the ATSDR minimal risk level (MRL).

Reference Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a media where noncancer health effects are unlikely. RMEGs are derived from EPA's reference dose (RfD).

Regional Screening Levels (RSLs) are chemical-specific concentrations developed by EPA for individual contaminants in air, drinking water and soil that may warrant further investigation or site cleanup. RSLs are not cleanup standards.

Lifetime Health Advisories (LTHAs) are contaminant concentrations in drinking water that are not expected to cause any noncancer health effects for a lifetime of exposure. LTHAs are derived by EPA but are not legally enforceable standards.

Maximum Contaminant Levels (MCLs) are enforceable standards set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (the level of a contaminant in drinking water below which there is no known or expected risk to health) as feasible using the best available treatment technology and taking cost into consideration.

Some CVs may be based on different durations of exposure. Acute duration is defined as exposure lasting 14 days or less. Intermediate duration exposure lasts between 15 and 364 days, and chronic exposures last 1 year or more. CVs based on chronic exposure studies are used when available. If an intermediate or acute CV is used, it is denoted with a small *i* or *a* before the CV (e.g., iEMEG refers to the intermediate duration EMEG).

Appendix C. Supplemental Tables for Surface Water Permit and Discharge Data

Table C.1 Permit Limits and Highest Reported Values for General Monitoring of Effluent Outfalls at Radford Army Ammunition Plant

Effluent Outfall #	Flow, Million Gallons per Day			pH		Sulfates			Total Suspended Solids		
	Limit	Highest Reported Monthly Average	Highest Reported	pH Range Allowed	Months with pH Excursions* / Total Months of Data	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit, Monthly Average	Limit, Maximum	Highest Reported Value
005	None	0.80	2.5	6-9	3 / 42	19,000 kg/d (2,100 mg/L)	21,000 kg/d (3,000 mg/L)	2,762 kg/d (2490 mg/L)	None	None	420 mg/L
006	None	16	20	6-9	1 / 42	-	None	8 mg/L	-	-	-
007	None	5.2	6.3	6-9	8 / 42	50,000 kg/d (2,100 mg/L)	59,000 kg/d (3,000mg/L)	32,391 kg/d (1,990 mg/L)	388 kg/d (40/mg/L)	1,261 kg/d (80 mg/L)	550 kg/d (30 mg/L)
014	None	0.20	0.20	6-9	0 / 42	-	None	26 kg/d	-	-	-
024	None	0.00004	0.00004	6-9	0 / 1	-	None	6 kg/d	30 mg/L	60 mg/L	26 mg/L
026	None	0.37	0.83	6-9	1 / 42	-	None	42.4 kg/d	114 kg/d (30/mg/L)	170 kg/d (45 mg/L)	78.3 kg/d (34 mg/L)
028	None	no data	no data	6-9	no data	-	None	no data	7.9 kg/d (30 mg/L)	11.9 kg/d (45 mg/L)	no data
029	None	1.5	2.6	6-9	0 / 38	3000 kg/d	6000 kg/d	138 kg/d (65 mg/L)	149.1 kg/d	484.2 kg/d	235.2 kg/d (49 mg/L)
291	None	0.10	0.20	-	-	-	-	-	-	-	-
402	None	0.50	0.50	6-9	1 / 39	None	None	4,270 mg/L	-	-	-

* pH excursions refer to periods of operation outside permit range, ranging from minutes to several hours, often due to spills or other process upsets. Notification and response actions required.
mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
kg/d = kilograms per day
no data = no data collected due to lack of flow or operation

Table C.1, continued

Effluent Outfall #	Oxidized Nitrogen			Temperature		Heat Rejected	
	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit	Highest Reported Value	Limit, Maximum	Highest Reported Value
005	None	None	76.5 mg/L	None	41°C	518 Million BTU per Day (MBTU/d)	376 MBTU/d
006	-	None	10 mg/L	None	40°C	5208 MBTU/d	2886 MBTU/d
007	6000 kg/d	10000 kg/d	6552 kg/d (395 mg/L)	50°C (May-Oct); 35°C (Nov-Apr)	39°C (May-Oct); 34°C (Nov-Apr)	-	-
014	-	None	3.7 mg/L	-	-	-	-
024	-	None	0.2 mg/L	-	-	-	-
026	-	None	14.5 mg/L	-	-	-	-
028	-	None	no data	-	-	-	-
029	None	None	46 mg/L	None	36°C	291 MBTU/d	215 MBTU/d
291	-	-	-	-	-	-	-
402	None	None	1.6 mg/L	None	27°C	-	-

mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
kg/d = kilograms per day
no data = no data collected due to lack of flow or operation

Table C.1, continued

Effluent Outfall #	5-Day Biological Oxygen Demand			Chemical Oxygen Demand			Acute Whole Effluent Toxicity	
	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit, Maximum	Highest Reported Value
005	-	None	59 mg/L	None	None	1,720 mg/L	-	-
006	-	None	7 mg/L	-	None	42 mg/L	1 Toxicity Units - acute (TU-a)	1 TU-a
007	233 kg/d (24 mg/L)	621 kg/d (64 mg/L)	716 kg/d (44 mg/L)	-	None	84 mg/L	6.6 TU-a	2.38 TU-a
014	-	None	9 mg/L	-	None	18 mg/L	-	-
024	-	None	<QL	-	None	12 mg/L	-	-
026	114 kg/d (30/mg/L)	170 kg/d (45 mg/L)	30.6 kg/d (20 mg/L)	-	None	35 mg/L	-	-
028	7.9 kg/d (30 mg/L)	11.9 kg/d (45 mg/L)	no data	-	None	no data	-	-
029	91.2 kg/d (60 mg/L)	243.6 kg/d (120 mg/L)	29 mg/L	319.3 kg/d (200 mg/L)	852.6 (290 mg/L)	559.2 kg/d (157 mg/L)	1 TU-a	2.56 TU-a
291	-	-	-	-	-	-	-	-
402	-	-	-	-	-	-	-	-

mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
kg/d = kilograms per day
no data = no data collected due to lack of flow or operation

Table C.1, continued

Effluent Outfall #	TNT Nitrobodies			Ammonia as N			Total Residual Chlorine		
	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit, Monthly Average	Limit, Maximum	Highest Reported Value	Limit, Monthly Average	Limit, Maximum	Highest Reported Value
005	-	-	-	-	-	-	-	-	-
006	-	-	-	-	-	-	-	-	-
007	-	-	-	-	-	-	-	-	-
014	-	-	-	-	-	-	-	-	-
024	-	-	-	3.14 mg/L	3.14 mg/L	<QL	-	-	-
026	-	-	-	10.6 mg/L	13.4 mg/L	4.9 mg/L	0.087 mg/L	0.10 mg/L	<QL
028	-	-	-	-	-	-	0.10 mg/L	0.10 mg/L	no data
029	-	-	-	-	-	-	-	-	-
291	0.9 kg/d	1.3 kg/d	<QL	-	-	-	-	-	-
402	-	-	-	-	-	-	-	-	-

mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
kg/d = kilograms per day
no data = no data collected due to lack of flow or operation

Table C.2. Permit Limits and Highest Detections for Other Organic and Metal Compounds for Outfalls 007 and 029

Compound	Outfall 007			Outfall 029		
	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d
1,1,1-Trichloroethane	0.21	0.57	<QL	0.077	0.19	<QL
1,1,2-Trichloroethane	0.31	1.23	<QL	0.077	0.19	<QL
1,1-Dichloroethane	0.21	0.57	<QL	0.08	0.21	<QL
1,1-Dichloroethylene	0.21	0.58	<QL	0.059	0.091	<QL
1,2,4-Trichlorobenzene	1.9	7.7	<QL	0.24	0.51	<QL
1,2-Dichlorobenzene	1.9	7.7	<QL	0.28	0.59	<QL
1,2-Dichloroethane	1.75	5.57	<QL	0.24	0.77	<QL
1,2-Dichloropropane	1.9	7.7	<QL	0.55	0.84	<QL
1,2-trans-Dichloroethylene	0.24	0.64	<QL	0.077	0.19	<QL
1,3-Dichlorobenzene	1.38	3.69	<QL	0.11	0.16	<QL
1,3-Dichloropropylene	1.9	7.7	<QL	0.1	0.16	<QL
1,4-Dichlorobenzene	1.38	3.69	<QL	0.055	0.1	<QL
2,4-Dichlorophenol	-	-	-	0.14	0.41	<QL
2,4-Dimethylphenol	0.18	0.46	<QL	0.066	0.13	<QL
2,4-Dinitrophenol	11.71	41.61	<QL	0.26	0.45	<QL
2,4-Dinitrotoluene	-	None	<QL	0.41	1.04	<QL
2,6-Dinitrotoluene	-	-	-	0.93	2.34	<QL
2-Chlorophenol	-	-	-	0.11	0.35	<QL
2-Nitrophenol	0.63	2.24	<QL	0.15	0.25	<QL
3,4-Benzofluoranthene	0.19	0.47	<QL	0.084	0.22	<QL
4,6-Dinitro-o-cresol	0.76	2.69	<QL	0.28	1.01	<QL
4-Nitrophenol	1.57	5.59	<QL	0.26	0.45	<QL
Acenaphthene	0.18	0.46	<QL	0.08	0.21	<QL
Acenaphthylene	0.18	0.46	<QL	0.08	0.21	<QL
Acrylonitrile	0.91	1.72	<QL	0.35	0.88	<QL
Anthracene	0.18	0.46	<QL	0.08	0.21	<QL
Benzene	0.55	1.3	<QL	0.13	0.49	<QL
Benzo(a)anthracene	None	None	<QL	None	None	<QL

Table C.2, continued

Compound	Outfall 007			Outfall 029		
	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d
Benzo(a)pyrene	None	None	<QL	None	None	<QL
Benzo(k)fluoranthene	None	None	<QL	None	None	<QL
Bis(2-ethylhexyl)phthalate	0.92	2.5	<QL	0.37	1.02	<QL
Carbon tetrachloride	1.38	3.69	<QL	0.066	0.13	<QL
Chlorobenzene	1.38	3.69	<QL	0.055	0.1	<QL
Chloroethane	1.07	2.86	<QL	0.38	0.98	<QL
Chloroform	1.08	3.15	<QL	0.077	0.16	<QL
Chrysene	None	None	<QL	None	None	<QL
Diethyl phthalate	0.45	1.1	<QL	0.29	0.74	<QL
Dimethyl phthalate	0.18	0.46	<QL	0.069	0.17	<QL
Di-n-butyl phthalate	0.19	0.42	<QL	0.099	0.2	<QL
Ethylbenzene	1.38	3.69	<QL	0.11	0.39	<QL
Fluoranthene	0.21	0.52	<QL	0.091	0.24	<QL
Fluorene	0.18	0.46	<QL	0.08	0.21	<QL
Hexachlorobenzene	None	None	<QL	None	None	<QL
Hexachlorobutadiene	1.38	3.69	<QL	0.073	0.17	<QL
Hexachloroethane	1.9	7.7	<QL	0.077	0.19	<QL
Methyl chloride	1.07	2.86	<QL	0.31	0.69	<QL
Methylene chloride	0.35	1.65	<QL	0.14	0.32	<QL
Naphthalene	0.18	0.46	<QL	0.08	0.21	<QL
Nitrobenzene	21.69	45.18	<QL	0.099	0.24	<QL
N-Nitroso-diphenylamine	-	None	<QL	-	None	<QL
Pheneanthrene	0.18	0.46	<QL	0.08	0.21	<QL
Phenol	0.18	0.46	<QL	0.055	0.095	<QL
Pyrene	0.19	0.47	<QL	0.091	0.24	<QL
Tetrachloroethylene	0.5	1.59	<QL	0.08	0.2	<QL
Toluene	0.27	0.72	<QL	0.095	0.29	<QL

Table C.2, continued

Compound	Outfall 007			Outfall 029		
	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d
Trichloroethylene	0.25	0.67	<QL	0.077	0.19	<QL
Vinyl Chloride	None	None	<QL	None	None	<QL
Total Chromium	10.76	26.86	0.34	4.05	10.1	<QL
Total Copper	14.06	32.78	0.24	5.3	12.3	0.17
Total Cyanide	4.07	11.64	1.52	1.53	4.38	<QL
Total Lead	3.1	6.69	<QL	1.17	2.52	0.22
Total Nickel	16.39	38.6	0.63	6.17	14.55	<QL
Total Zinc	10.18	25.31	0.36	3.83	9.54	0.08

Notes:

The highest reported value for Total Chromium and Total Copper occurred in the July 2011-September 2011 reporting period; average monthly flow was 3.80 MGD.
The highest reported value for Total Cyanide and Total Nickel occurred in the July 2010-June 2011 reporting period; average monthly flow was 4.12 MGD.
The highest reported value for Total Zinc occurred in the October 2011-December 2011 reporting period; average monthly flow was 4.02 MGD.

kg/d = kilograms per day MGD = million gallons per day

Table C.3 Permit Limits and Highest Reported Values for Outfall 999

Parameter	Limit (Monthly Average) in kg/d	Limit (Maximum) in kg/d	Highest Reported Value in kg/d
Sulfates	50,000	75,000	32,944
Total Suspended Solids	6,200	9,300	751
Oxidized Nitrogen	6,600	10,000	5,406
5-Day Biological Oxygen Demand	6,700	10,000	890
Chemical Oxygen Demand	14,500	22,000	2,704
Vinyl Chloride	0.9	1.36	<QL
Chrysene	0.18	0.26	<QL
Benzo(a)anthracene	0.18	0.26	<QL
Benzo(a)pyrene	0.18	0.26	<QL
Benzo(k)fluoranthene	0.18	0.26	<QL
Hexachlorobenzene	0.03	0.04	<QL

Notes:
<QL = below quantitation limit
kg/d = kilograms per day
Outfall 999 represents the mathematical sum of all final effluent outfalls.

Table C.4. Permit Limits and Highest Reported Values for Monitoring of Stormwater Outfalls at Radford Army Ammunition Plant

Stormwater Outfall #	Estimated Volume of Rain Event, Million Gallons		pH		Sulfate	
	Limit	Highest Rain Event Volume	Range Allowed	Months with pH Excursions / Total Months of Data	Limit, Maximum	Highest Reported Value
004	None	0.58	6-9	0 / 15	None	3,150 mg/L
012	None	0.01	6-9	0 / 7	None	30 mg/L
017	None	no data	None	no data	-	-
041	None	0.29	-	-	-	-
044	None	0.16	-	-	-	-
050	None	0.06	-	-	-	-
054	None	0.04	-	-	-	-
401	None	0.24	6-9	0 / 8	-	-

µg/L = micrograms per liter
mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
no data = no data collected due to lack of flow or operation

Table C.4, continued

Stormwater Outfall #	TSS		Nitrate/ Nitrite		Oil & Grease	
	Limit, Maximum	Highest Reported Value	Limit, Maximum	Highest Reported Value	Limit, Maximum	Highest Reported Value
004	-	-	NL	1.1 mg/L	-	-
012	-	-	-	-	-	-
017	None	no data	-	-	-	-
041	None	47 mg/L	-	-	None	<QL
044	None	102 mg/L	-	-	None	5 mg/L
050	None	416 mg/L	None	1.5 mg/L	None	<QL
054	None	19 mg/L	-	-	-	-
401	50 mg/L	62 mg/L*	-	-	-	-

µg/L = micrograms per liter
mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
no data = no data collected due to lack of flow or operation
*TSS exceedance attributed to July 2010 unusually large rain event / flow through outfall before solids could settle in clarifier. No other exceedances.

Table C.4, continued

Stormwater Outfall #	Dissolved Copper		Dissolved Lead		Dissolved Zinc	
	Limit, Maximum	Highest Reported Value	Limit, Maximum	Highest Reported Value	Limit, Maximum	Highest Reported Value
004	-	-	-	-	-	-
012	-	-	-	-	-	-
017	None	no data	None	no data	None	no data
041	-	-	-	-	-	-
044	-	-	-	-	-	-
050			None	0.0016 µg/L	-	-
054	-	-	-	-	None	11.3 µg/L
401	-	-	-	-	-	-

µg/L = micrograms per liter
mg/L = milligrams per liter
<QL = below quantitation limit
"-" = no monitoring/reporting required
no data = no data collected due to lack of flow or operation

Appendix D. Community Concerns and Responses

Note: The following appendix has not been changed significantly from the public comment draft health consultation. Several concerns, particularly those regarding air exposures, were raised again in the public comments received on the draft report. Please see expanded responses to these concerns in the public comments section in Appendix E beginning on page 100 of this report.

In conducting public health activities, ATSDR attempts to respond to communities' health concerns about the site. ATSDR collected community concerns via the following methods:

- Information shared by other federal, state, and local agencies with a history of work at the site
- Telephone and email correspondence between ATSDR and community members
- A public availability session sponsored by ATSDR. The availability session was held at Belview Elementary School near RFAAP from 6:30-8:00 pm on January 24, 2013. The session was advertised with an announcement to local media outlets and through electronic media and door-to-door activities of local stakeholders. Community members; federal, state, and local agencies; and facility operators were invited to share information and concerns about the site. Concerns were collected by ATSDR staff and our partners at the Virginia Department of Health.
- Responses shared by a local environmental group from a health survey they conducted by mail in the area surrounding RFAAP in winter and spring 2013.

This appendix compiles the concerns expressed by residents and other interested people about RFAAP. ATSDR's responses are shown in plain text. *Concerns that were similar in nature and subject are numbered separately but grouped together, with one response following the concerns.*

Water Related Concerns

Related concerns addressed by following response:

1. Many general concerns with safety of [well] water, even if not used for drinking.
2. Concern about source of sediment in well water of property about 1 mile from RFAAP boundary and close to a municipal water treatment plant. Well installed in 2002 and water fine for a year or so then became cloudy. Also noticed that frogs and toads which used to be prevalent are not there anymore.
3. Concern that well water (properties downstream from RFAAP) may harm garden. Certain plants in garden (cucumbers) do not grow any more.

ATSDR found that private wells in the area surrounding RFAAP are not affected by contaminants from the facility. However, drinking water wells are sensitive to a number of different factors. Well construction, naturally occurring substances in bedrock, and surface water

flowing through local karst formations can all affect quality of the water obtained from wells. ATSDR recommends well owners have their well water tested periodically to ensure it is of good quality. For more information about well maintenance and treatment, visit Centers for Disease Control and Prevention's (CDC) website for "Private Ground Water Wells" (http://www.cdc.gov/healthywater/drinking/private/wells/index.html). The Virginia Cooperative Extension Service also has several publications on water quality and best practices for well maintenance on their website at http://www.pubs.ext.vt.edu/category/home-water-quality.html. For questions on home gardening, please contact your local Virginia Cooperative Extension Office. For Montgomery County, see http://offices.ext.vt.edu/montgomery/ or call (540) 382-5790, and for Pulaski County, see http://offices.ext.vt.edu/pulaski/ or call (540) 980-7761. Several gardening-related publications are also available at the Virginia Cooperative Extension Service website (http://www.pubs.ext.vt.edu).

4. Contaminants may travel in karst for long distances and affect water quality of private wells located within a few miles of RFAAP

Groundwater in karst can flow for relatively long distances and in directions difficult to predict; however, the groundwater at RFAAP has been shown to travel towards the New River or other surface water outlets ultimately joining the river flow. No private wells intercept the path of groundwater flow from RFAAP.

5. Contaminated groundwater from the OBG is connected with private wells through faults, fissures, sinkholes and unpredictable water flow.

Groundwater contaminants from the Open Burning Ground are in the soil and sediment materials above the bedrock, and the groundwater flows directly toward the adjoining New River. These contaminants cannot reach private wells in the area.

6. ATSDR should conduct testing of private and public wells for the contaminants in the groundwater at RFAAP.

ATSDR rarely conducts environmental testing. Recent testing of nearby private wells by a local environmental group did not show any elevated levels of contaminants that were identified as a concern at RFAAP.

7. Does the HRS listing need to be revisited since updated groundwater mobility factors have been updated to include separate values for karst- and non-karst-systems?

In the March 31, 2012 update to the Superfund Chemical Data Matrix (see http://www.epa.gov/superfund/sites/npl/hrsres/tools/volatile-substances-factor-values.pdf), the groundwater mobility factors that are different for karst and non-karst systems are those for substances that tightly bind to soil particles, such as semi-volatile organic compounds. These substances have not been detected frequently or at high levels in most studies of RFAAP. The substances which have been of greater concern at various units of the site (such as TCE, metals, or explosive compounds) have the same factors for either karst or non-karst.

8. Virginia Department of Mines and Minerals has documented numerous sinkholes and caves in the karst terrain beneath the Arsenal's Main Manufacturing Area. A dye tracer study conducted at RFAAP early on in the clean up process showed that groundwater discharges at unknown locations. This karst terrain provides a route of exposure by cross-contamination of groundwater.

It is ATSDR's understanding that caves have not been documented at the RFAAP Main Manufacturing Area. The dye trace study showed that dye injected at one point discharged (under both low- and high-flow conditions) at a spring along the New River. The other injection point in the study failed because the dye did not enter the karst formation.

9. There is no record of drinking water well test results requested by EPA in the HRS Deficiency Report.

The commenter references a report included in reference [18], the 1992 Preliminary Assessment Addendum. The results were included in that reference and have been summarized in this health consultation beginning on page 23.

10. The source for the TCE plume at HWMU5 has not been identified so there could be very high concentrations traveling through karst features from far away.

No distant source for the TCE has been found. The plume has been characterized to emanate from HWMU 5 and does not reach down to the bedrock. There is no evidence that higher concentrations of TCE are traveling through karst features.

11. The TCE plume at HWMU 5 is not undergoing natural attenuation because no daughter products have been detected.

Natural attenuation is the reduction in mass or concentration of a compound in groundwater over time or distance from a source due to naturally occurring physical, chemical, and biological processes. These processes can include biodegradation to daughter products as well as plant or animal uptake, dispersion, dilution, adsorption, volatilization, or chemical reactions such as complexation.

12. TCE has been documented in Giles county Water, and PCE has been documented in the Blacksburg/Christiansburg-VPI Water Authority from 2004-2009. This could be coming from HWMU 5.

ATSDR was not able to verify these statements about PCE and TCE in nearby public water systems. The TCE plume at HWMU5 has been characterized and is stable. Giles County obtains its water from wells located more than 10 miles from HWMU5, and the Blacksburg/Christiansburg/VPI Water Authority obtains its water from the New River upstream of RFAAP. These sources are not affected by HWMU5.

13. Radioactive isotopes could be in the water from RFAAP's work with depleted uranium.

ATSDR does not have any information about depleted uranium at RFAAP. Some unit-specific investigations and compliance monitoring have included tests for radioactive compounds, but none were detected at levels of concern.

14. 26 ppb for perchlorate at the OBG is not protective. ATSDR's tox profile states that DOD will conduct a site specific risk assessment if perchlorate levels exceed 24 ppb in water.

A concentration of 26 ppb is higher than ATSDR's comparison value for perchlorate in drinking water of 7 ppb. However, the groundwater at the Open Burning Ground is not used for drinking water. Groundwater at the Open Burning Ground flows towards the New River, where it is diluted by a factor of at least 1,000.

ATSDR's toxicological profile for perchlorates describes the Department of Defense's policy as it existed when the profile was published in 2008 and states beginning on page 12, "Specifically, the DOD's policy states that in the absence of federal or state standards, if perchlorate levels in water exceed 24 ppb (current level of concern for managing perchlorate), a site-specific risk assessment must be conducted. When an assessment indicates that the perchlorate contamination could result in adverse health effects, the site must be prioritized for risk management." [100] The Open Burning Ground is subject to VDEQ standards defined in the Hazardous Waste Management Operating Permit and Post-Closure Care Permit, so this stipulation would not apply; moreover, the DOD policy may have changed since 2008 (searches for DOD policies and guidance can be performed at http://www.denix.osd.mil). As a non-regulatory agency, ATSDR does not direct the actions of other agencies.

15. How will [the local Sierra Club group conducting well sampling] decide what water will be tested?

ATSDR did not actively participate in this well sampling effort. Please check the group's website at http://nrvsierraclub.com/ to find contacts.

16. Concern that water supplied by RFAAP to Prices Fork/Merrimac system may have high levels of lead. Anecdotal information about children in Prices Fork testing very high for blood lead.

Lead has not been detected in drinking water samples from the distribution system supplying the Prices Fork/ Merrimac area. In 2011, four locations for consumer tap sampling exceeded the action level for lead. It is possible that sampling error contributed to the results as re-testing did not show exceedances. Home plumbing fixtures could also contribute lead to tap water. There are many possible sources of lead in the environment which could contribute to a child's blood lead level. Residents should discuss concerns about lead exposure with their local health department or medical care provider.

17. Does the Safe Drinking Water Act apply to water from RFAAP supplied to the Prices Fork/ Merrimac area?

Yes.

18. Many contaminants in the groundwater at RFAAP are not included in the testing required for public water supplies.

ATSDR found that public water supplies are not affected by RFAAP because they obtain water from the New River upstream of RFAAP. Testing of these systems for RFAAP contaminants is not necessary.

19. Consumer confidence reports for some public water systems in the area (Bethel, Christiansburg, Mudpike) did not test for lead. Why?

Testing is performed for all substances required, but consumer confidence reports generally only list substances that are detected. Some contaminants are on different schedules and may not be tested as frequently as others. Please contact your public water system directly about their specific testing information.

20. Concern that mussels do not grow anymore in the New River. Are they affected by nitrates from RFAAP?

ATSDR did not evaluate ecological exposures in this document. The Virginia Department of Environmental Quality evaluates the ecological health of the State's streams and rivers. For more information visit VADEQ's Biological Monitoring program at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/BiologicalMonitoring.aspx

21. Recreational uses of the New River include fishing, swimming, floating and full body contact with river water. Is this safe given the releases into the river from RFAAP?

ATSDR did not evaluate recreational exposures in this document. However, we did note that after surface water releases from RFAAP mix with the New River, the contaminant concentrations will be below drinking water comparison values. Virginia's Department of Environmental Quality is in charge of assessing the conditions of freshwater streams for their respective designated uses. Please contact VADEQ's Water Quality program at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments.aspx. The New River near RFAAP is not listed as impaired for recreational use.

22. Anecdotal information that people swimming with open wounds in the New River have had rashes, irritation, and chronic infection.

Please see previous response to concern #21. In addition to RFAAP, there are several municipal waste water outfalls into the New River in this area, and surface runoff can carry waste from animals or agriculture directly into the river. It is a good practice for people with open wounds to avoid exposing them to surface water in general.

23. Companies are promoting catch and release fishing on the New River.

Please see previous response to concern #21. There is a fish consumption advisory for this section of the New River based on PCB levels in fish. Catch and release fishing would not be restricted by this advisory. PCBs are a general problem and not specifically related to RFAAP.

24. Some people downstream of RFAAP do eat the fish they catch from the new River.

The fish advisory (which applies to the New River from below Claytor Dam to the West Virginia border) states that people should not eat carp from this section of the New River and should not eat more than two meals a month of flathead catfish or channel catfish. PCBs are a general problem and not specifically related to RFAAP. The specifics of the advisory can be found on the Virginia Department of Health website: http://www.vdh.state.va.us/Epidemiology/DEE/publichealthtoxicology/Advisories/NewRiver.htm

Health Outcome Related

25. Concerns about skin conditions, heart conditions, asthma and other respiratory diseases, blood lead levels in children, breast cancer, and thyroid cancer.

ATSDR did not identify a completed drinking water exposure pathway from RFAAP; therefore, this pathway is not contributing to these conditions, whether or not they are elevated.

26. Is there a way that the ATSDR can look at data on lead levels in children around the arsenal? Over a ton of lead is released from the OBG every year, which sounds like a possibly significant threat to me.

The Virginia Department of Health reports results of lead surveillance testing by county. ATSDR examined Annual Lead-Safe Virginia Summary Surveillance Reports from 2005-2011 available online at http://www.vdh.virginia.gov/leadsafe/data.htm. The findings for Montgomery and Pulaski Counties are summarized below. There does not appear to be an unusually high number of cases in either county. Many potential sources of lead exposure exist, including house dust or soil affected by lead-based paint, imported jewelry and toys, home health remedies, or imported herbs and spices. The New River Health District of the Virginia Department of Health investigates blood lead level cases greater than 20 µg/dL.

Montgomery County Lead Surveillance Findings, 2005-2011*

Year	Children <3 Years Old Tested	Children <3 Years Old With Confirmed Elevated Blood Lead Level (Level)	Children <6 Years Old Tested	Children <6 Years Old With Confirmed Elevated Blood Lead Level (Level)
2005	138	0	228	0
2006	141	1 (15-19 µg/dL)	282	2 (15-19, 20-44 µg/dL)
2007	181	0	317	0
2008	129	0	267	1 (20-44 µg/dL)
2009	62	1 (15-19 µg/dL)	181	2 (15-19 µg/dL)
2010	101	1 (10-14 µg/dL)	228	1 (10-14 µg/dL)
2011	75	0	132	0
Source: Virginia Department of Health. Annual Lead-Safe Virginia Summary Surveillance Reports. Available at: www.vdh.virginia.gov/leadsafe/data.htm				

*Note: Ten (10) µg/dL was used as the cutoff for elevated blood lead level. There is no safe blood lead level. Since 2012, CDC has recommended using the 97.5 percentile blood lead level in children from National Health and Nutrition Examination Survey (NHANES) data (5 µg/dL since 2012) as a reference level for determining elevated blood lead levels (see http://www.cdc.gov/nceh/lead/ACCLPP/blood_lead_levels.htm).

Pulaski County Lead Surveillance Findings, 2005-2011*

Year	Children <3 Years Old Tested	Children <3 Years Old With Confirmed Elevated Blood Lead Level (Level)	Children <6 Years Old Tested	Children <6 Years Old With Confirmed Elevated Blood Lead Level (Level)
2005	55	0	121	1 (20-44 µg/dL)
2006	205	0	487	1 (20-44 µg/dL)
2007	119	0	44	2 (10-14 µg/dL)
2008	207	0	407	1 (20-44 µg/dL)
2009	182	0	357	1 (20-44 µg/dL)
2010	178	0	264	0
2011	235	1 (45-69 µg/dL)	318	1 (45-69 µg/dL)

Source: Virginia Department of Health. Annual Lead-Safe Virginia Summary Surveillance Reports. Available at: www.vdh.virginia.gov/leadsafe/data.htm
*Note: Ten (10) µg/dL was used as the cutoff for elevated blood lead level. There is no safe blood lead level. Since 2012, CDC has recommended using the 97.5 percentile blood lead level in children from NHANES data (currently 5 µg/dL) as a reference level for determining elevated blood lead levels (see http://www.cdc.gov/nceh/lead/ACCLPP/blood_lead_levels.htm).

Air Related

27. ATSDR should evaluate the air exposure pathway.

No data exist describing the ambient air concentrations of contaminants released by RFAAP. ATSDR would need air concentration data from areas where people live to estimate potential air exposures with confidence. Such ambient air data would also include contaminants contributed by nearby local sources as well as RFAAP. The facility's air emissions are subject to permit requirements from VDEQ that are designed to be protective of public health.

Related concerns addressed by following response:

28. Concern about asbestos in particles from burns.
29. Several concerns that no studies have been done to address air.
30. Concern about community exposures from air releases from Open Burning Ground

ATSDR did not evaluate air emissions from RFAAP in this health consultation.

31. Maps from a risk assessment for the Open Burning Ground show the maximum impact area to the east and southeast of RFAAP. Virginia Tech operates a produce farm there near a fly ash pit. Could produce there be affected by open burning?

ATSDR did not evaluate air emissions from RFAAP in this health consultation. We do note that our site reconnaissance indicates that the Virginia Tech farm facility is actually located across the New River to the northwest of RFAAP.

32. RFAAP received a warning letter for exceeding the maximum burn rate for chromium at the Open Burning Ground. Was the public exposed to harmful levels of chromium? Are children at Belview Elementary (1 mile east/ southeast of RFAAP) exposed to contaminants from open burning at RFAAP?

ATSDR did not evaluate air emissions from RFAAP in this health consultation. Regulatory agencies use various tools and methods to determine environmental standards. These standards and/or target risk values have a margin of safety built around them to account for uncertainties and for preventing harmful effects from exposures. Occasional or small exceedances of these values will not usually result in harmful effects.

33. If the risk assessment for the Open Burning Ground is not sufficient for ATSDR to evaluate, it must not be valid.

The risk assessment relied on air modeling to reach its conclusions and is valid for its regulatory purpose. Air models predict or estimate chemicals in ambient air that may result from facility emissions. These modeled results do not necessarily represent an accurate picture of community exposures (and in many instances, modeled data overestimate actual air concentrations).

34. ATSDR recommended particulate monitoring at Picatinny Arsenal in NJ. Does RFAAP's failure to comply with EPA's 2006 rule on particulate matter constitute enough evidence for ATSDR to make an urgent recommendation to Enforcement and Compliance at EPA?

ATSDR did not evaluate the air pathway in this evaluation and therefore has not assessed the validity of the statement that RFAAP did not comply with EPA's particulate matter rules. ATSDR has made no recommendations regarding air at RFAAP.

35. Proposed permit modifications will allow BAE to burn more chromium in their skid burns. What are the associated exposure risks in our air, water, and soil?

Permitting decisions are the purview of environmental regulatory agencies, not ATSDR. ATSDR did not evaluate air emissions from RFAAP in this health consultation and does not have the data available to answer this question.

Other/ General

36. ATSDR should evaluate soil exposure route from RFAAP.

The public does not have access to the facility and therefore the community is not exposed to contaminants in soil.

37. ATSDR is not giving RFAAP the same level of scrutiny as at other Army Ammunition Plants.

When ATSDR receives a petition, it determines the amount and type of data available and determines whether a meaningful evaluation can be performed to answer the petitioner's concern. The determination of the evaluation performed is a site specific decision.

38. Concern that permitting/regulatory requirements are not protective of human health.

ATSDR is not a regulatory agency. Although our perspective and methods might differ, in general ATSDR does not doubt the validity of methods used by regulatory agencies to determine protective standards and requirements.

39. Tax dollars used to support the Arsenal should be used for sampling to ensure taxpayers aren't harmed.

ATSDR does not have authority to set funding priorities for other governmental agencies.

40. There should be more community meetings.

ATSDR plans to hold a community meeting to present the findings of this health consultation.

41. The public was not notified about spills occurring at RFAAP.

ATSDR is not a regulatory agency. The regulatory authority makes determinations about whether notification requirements were met.

42. The Arsenal should expand and create more jobs in the community.

ATSDR recognizes that there are differing perspectives in the community about the RFAAP site. ATSDR is an advisory public health agency and does not have authority over job creation issues.

Appendix E. Public Comments Received and ATSDR Responses

A draft of this health consultation was available for public review and comment in spring 2014 at the Radford Public Library in Radford, Virginia and at the Montgomery-Floyd Regional Library in Christiansburg, Virginia. The document was also available for viewing or downloading from the ATSDR web site and was provided electronically to residents and other interested parties on ATSDR's electronic mailing list for the site. The public comment period was open from April 23, 2014 through May 23, 2014; additional public comments received through June 2014 were also accepted.

The public comment period was announced to local media outlets. ATSDR presented and discussed the findings of the draft health consultation with community members at a public meeting held May 1, 2014 at Belview Elementary School in Radford, Virginia. ATSDR also met informally with representatives of local environmental groups to discuss the findings on April 30 and May 1 before the public meeting. Copies of the draft report and a fact sheet summarizing the findings were also provided to the community during the public meeting.

General Response to Concern About Air Exposures

Based on our discussions with community members and written comments included in the Appendix of this report, a major concern of the community is the possibility of air exposures, particularly potential exposures from open burning at RFAAP. ATSDR acknowledges the community's concern and recognizes the lack of air sampling results as a data gap in the assessment of community exposures. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider the air-related public comments we received on this drinking water health consultation. ATSDR's findings on the air pathway will be conveyed in a separate report.

Specific Public Comments Received

ATSDR received written comments from eight people. The comments received are listed in their entirety below (with personal identifying information removed). The comments were not changed but were split and numbered by ATSDR into specific comments that were responded to individually. In addition, we corrected some obvious typographical errors and made font changes throughout to make the comments more readable and consistent. ATSDR responses are inserted as italicized text. Notes and any removed text are indicated in a different font. For the convenience of the reader, references in these responses are shown as footnotes as well as in the Reference section of the complete document.

Specific comments follow.

Comments from Public Commenter #1 (PC1):

PC1-1: The U.S. Army MERIT report states that perchlorate was found in 16:16 groundwater wells tested at the facility in 2010, including a high of 148 ppb from HWMU13, the groundwater beneath the Open Burning Ground (OBG).

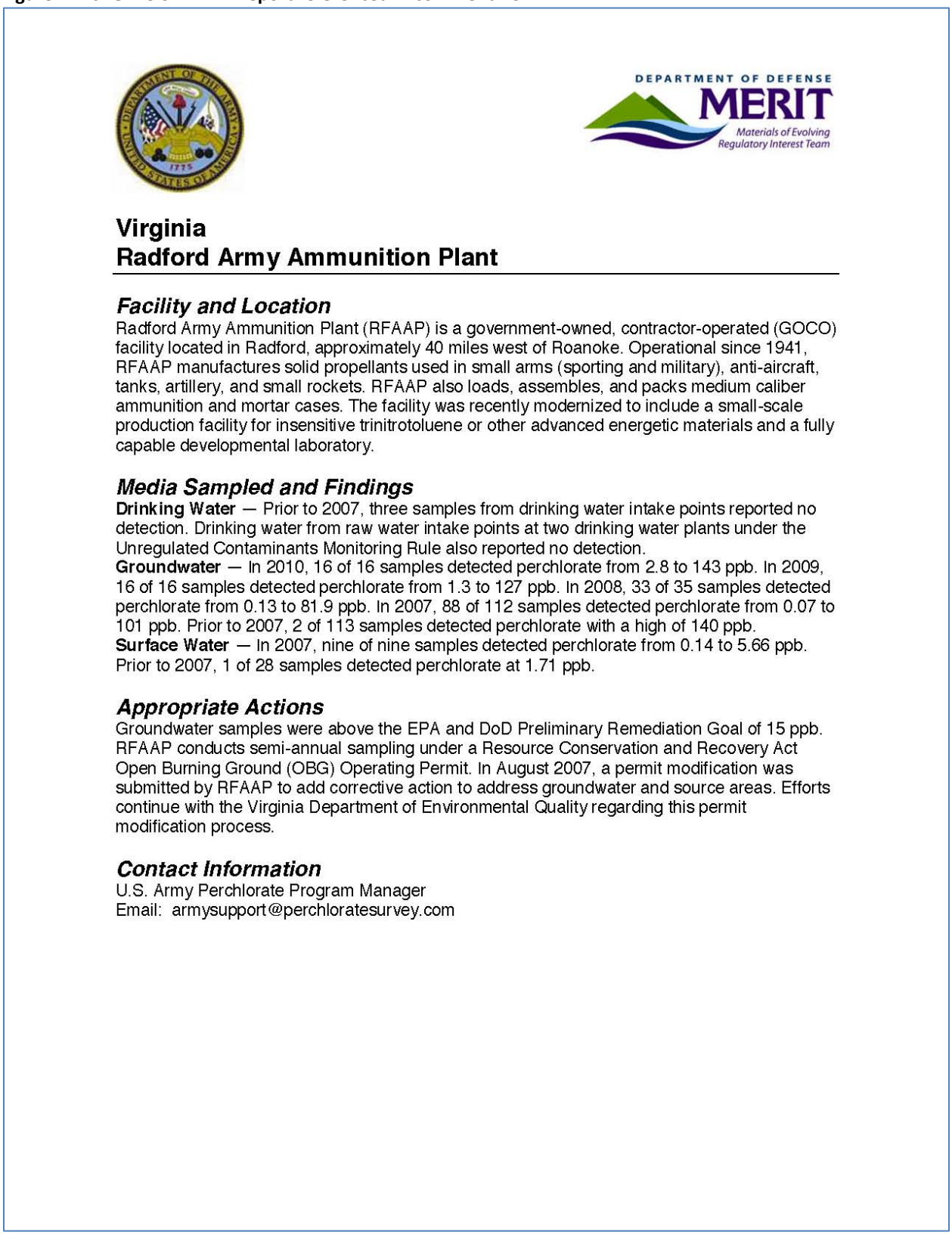
[note the US Army MERIT report referenced in this comment was attached via email with this set of electronic comments and is shown in Figure E-1 on the following page. The MERIT fact sheet actually lists the highest concentration of perchlorate as 143 ppb, the same value found by ATSDR in our evaluation of site data. The conclusion and our response are the same whether the actual high value is 143 or 148 ppb.]

ATSDR Response: ATSDR tried to access the email listed on the fact sheet in Figure E-1 but it was not functioning, so we contacted the Department of Defense (DOD) liaisons for this site [personal communication, Jim McKenna, RFAAP, and Ronie Shackelford, DOD, June 6, 2014 and June 19, 2014]. They provided the following information about the source of data in the MERIT report referenced. The data are from the DOD Environment, Safety and Occupational Health Network and Information Exchange website (http://www.denix.osd.mil/perchloratesummaries/statesm-z/virginia.cfm). The fact sheet that referenced 16 of 16 test wells with detectable perchlorate was prepared by the Materials of Evolving Regulatory Interest Team (MERIT). MERIT summarized perchlorate groundwater data provided by RFAAP in fact sheets published from 2009 to 2011. The 2011 fact sheet is the one provided in Figure E-1 on the next page. The MERIT fact sheet summaries are no longer being produced. The fact sheets did not specify the exact location of the samples, so it is impossible to verify the accuracy of all the statements in the fact sheet. ATSDR considered data from original reports from RFAAP, which included the data used to compile the MERIT summary. For example, the highest perchlorate concentration in groundwater at the Open Burning Ground in 2010 was 143 micrograms per liter, a figure cited in the fact sheet. Not all sites on RFAAP had high levels of perchlorate in groundwater.

PC1-2: The OBG is used nearly every day to burn hazardous materials including chromium, aluminum, barium and other wastes from contractors at the facility, such as Grucci Fireworks and Alexander Arms. The OBG waste steam contains lead and perchlorate, which seems to indicate that the current operation of the OBG presents a clear and present danger to our community in violation of RCRA Statutes 7002 & 7003.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider the air-related public comments we received on this drinking water health consultation. ATSDR's findings on the air pathway will be conveyed in a separate report.

Figure E-1. JPG file of MERIT report referenced in comment PC1-1.



DEPARTMENT OF DEFENSE
MERIT
Materials of Evolving Regulatory Interest Team

Virginia
Radford Army Ammunition Plant

Facility and Location

Radford Army Ammunition Plant (RFAAP) is a government-owned, contractor-operated (GOCO) facility located in Radford, approximately 40 miles west of Roanoke. Operational since 1941, RFAAP manufactures solid propellants used in small arms (sporting and military), anti-aircraft, tanks, artillery, and small rockets. RFAAP also loads, assembles, and packs medium caliber ammunition and mortar cases. The facility was recently modernized to include a small-scale production facility for insensitive trinitrotoluene or other advanced energetic materials and a fully capable developmental laboratory.

Media Sampled and Findings

Drinking Water — Prior to 2007, three samples from drinking water intake points reported no detection. Drinking water from raw water intake points at two drinking water plants under the Unregulated Contaminants Monitoring Rule also reported no detection.
Groundwater — In 2010, 16 of 16 samples detected perchlorate from 2.8 to 143 ppb. In 2009, 16 of 16 samples detected perchlorate from 1.3 to 127 ppb. In 2008, 33 of 35 samples detected perchlorate from 0.13 to 81.9 ppb. In 2007, 88 of 112 samples detected perchlorate from 0.07 to 101 ppb. Prior to 2007, 2 of 113 samples detected perchlorate with a high of 140 ppb.
Surface Water — In 2007, nine of nine samples detected perchlorate from 0.14 to 5.66 ppb. Prior to 2007, 1 of 28 samples detected perchlorate at 1.71 ppb.

Appropriate Actions

Groundwater samples were above the EPA and DoD Preliminary Remediation Goal of 15 ppb. RFAAP conducts semi-annual sampling under a Resource Conservation and Recovery Act Open Burning Ground (OBG) Operating Permit. In August 2007, a permit modification was submitted by RFAAP to add corrective action to address groundwater and source areas. Efforts continue with the Virginia Department of Environmental Quality regarding this permit modification process.

Contact Information

U.S. Army Perchlorate Program Manager
Email: armysupport@perchloratesurvey.com

PC1-3: Although the facility contractor has refused to conduct ambient air quality monitoring, a 2005 Health Risk Assessment performed by CH2MHill for ATK noted that "skid burns" at the OBG release more dioxin and furans than the Hazardous Waste Incinerators and ought to be "mitigated." Despite this advice, no change to the "skid burn" process has been implemented. (Please see section 7.0 of the SCLERA portion of that HHRA for details.) Is it feasible for your agency to use this CH2MHill HHRA to assess our potential exposure risk from OBG emissions?

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC1-4: Although the facility does not report output from the OBG to the EPA on the Toxic Release Inventory, the poisonous particulate matter (PM) from this point source are inhaled by the children living here. Those attending Belview Elementary School are just 1.5 miles downwind of each burn and the PM falls to soil where it then washes into our groundwater table. This OBG data ought to be carefully considered in analyzing our risk of potential toxic exposure.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC1-5: Further details about the OBG and other point sources of contamination with completed exposure pathways is contained in the EPA Multi-Media Inspection conducted from May 16 - 20, 2011. This important data was available to ATSDR, but not included in the draft assessment. Our community implores the ATSDR to obtain the 2011 EPA inspection report to analyze and include its findings relative to our exposure risk. Select excerpts are included here for your convenience.

[Following indented text included by commenter in public comment]:

> Page 21:
> Lead Burning Shop
> This area was inspected by Mr. Young. Lead metal sheets and scrap was observed being accumulated outside and inside this building (see Photographs RCRA-C- 157 to 160). The lead is re-used for lining floors and trenches in the acid processing areas of the Facility. Some of the lead has been accumulated for one to two years. According to the Facility personnel present at the time of the inspection, the last time lead was re-used in a project was about three months ago.
> Waste Analysis Plan
> Multi-Media Inspection Report
> The Facility has developed waste profiles for 19 waste groups that are treated in the incinerators and open burning ground (see Attachment RCRA-C-2). There is a 20th waste group that consists of screening and floor waste that is managed at the OBG for which there is no waste profile because it can be a mixture of waste groups 1 through 19, excluding waste groups 2, 3, 5, and 6. The waste profiles are based both on

generator knowledge and laboratory analysis. Every waste profile is reviewed at least annually in order to confirm that it still accurately represents the waste stream.
The Facility has two written Waste Analysis Plans, one for the OBG and the other for the Incinerators Complex, as part of the Facility's RCRA Part B permit. The Plans include a list of wastes to be sampled, the location of the sampling, a list of parameters to be analyzed and the selection rationale, the test and sampling methods to be used, and the frequency of the sampling.
Ash from the OBG and the incinerators (including the solid residues generated by the Evaporative Cooler and the Bag House) is analyzed for reactivity and toxicity characteristics prior to being sent off-site for disposal. If the ash exhibits the hazardous waste characteristic of reactivity, it is re-treated by open burning at the OBG or, in the case of the ash from the incinerators, taken to the OBG for further treatment.
Pg 24
Air Emission Standards for Process Vents
During the inspection, Mr. Martinez did not observe any distillation, fractionation, solvent extraction, thin-film evaporation, air or steam stripping units with process vents that managed hazardous waste with greater than 10 parts per million by weight (ppmw)
of organics.
Air Emission Standards for Equipment Leaks
The Facility has identified, in the Incinerators Permit, several pumps, valves, and miscellaneous connections that contact the waste slurry (identified as a light liquid) before it is fed to the rotary kilns as subject to the air emission standards for equipment leaks. According to the Incinerators Permit, there are no compressors, pressure relief devices, sampling connecting systems, or open ended lines or valves as part of the incinerator systems that contact or contain waste with greater than 10 percent organics. During the inspection, Mr. Martinez did not observe any other hazardous waste management equipment that could potentially manage waste with greater than 10 percent organics and be subject to the air emission standards for equipment leaks.
According to the Incinerators Permit, the Facility has implemented a leak detection and repair (LDAR) program. The program consists of a vapor release monitoring program in combination with visual inspections of the equipment.
Air Emission Standards for. Tanks
Before being fed to the rotary kilns, the propellant waste material is mixed with water and accumulated in two 1,700-gallon, open top slurry mix tanks located in the basement of the Grind House (Building • · According to the Incinerators Permit, these two tanks are subject to the air emission standards for tanks; however, although according to the Incinerators Permit, Building . has been demonstrated to meet the criteria for a permanent or temporary enclosure; however, the permit exempts Building . from the requirement to discharge the enclosure's volatile organic chemical (VOC) emissions through a control device. The permit only requires the Facility to submit a triennial report that includes a survey of VOC control technologies and a feasibility determination.
From the CAA portion of the inspection:
pg.42
RFAAP is a major source of air pollutants, but many of the emissions units are older units that are not regulated by Federal standards. Consequently, large reductions of these air pollutants are unlikely without new standards being issued (e.g., the Boiler Maximum Achievable Control Technology (MACT) standards) or with replacement or major retrofitting of the units.
pg. 44
No prior CAA Title VI compliance evaluations for ODSs are known to have been conducted by EPA or VADEQ and no known enforcement actions related to ODSs have been taken.
Open Burning Ground
The Open Burning Ground is located along the New River shoreline and, according to - ' is used almost daily for burning of waste propellants, except when weather conditions do not allow burns. I observed a burn from the opposite shoreline that lasted for about 10 minutes and generated visible emissions (see Photographs CAA-1 and 2). A technician present during the burn reported that burns can last as long as two to three hours. This area is not specifically regulated by the Title V Permit or any other VADEQ CAA permit.
Hazardous Waste Incinerators

> According to - ' the two active HW is were installed and began operation in the 1970s and are used to destroy hazardous waste propellants generated from the production processes on-site. • • also reported that a third incinerator next to the other two had not been used since the 1970s. The incinerators were retrofitted with bag houses in 1993 and also have scrubbers for the final air emissions.
> pg.45
> reported the hazardous waste burned in the incinerators is reactive and fails the Toxicity Characteristic Leaching Procedure (TCLP) for lead and 2, 4-Dinitrotoluene. These incinerators are regulated but the Title V Permit and by the EPA MACT regulations in 40 CFR Part 63, Subpart EEE. Discussion of the review of records related to these incinerators is provided in the subsection below.
> ….
> Powerhouse Boilers
> Five large boilers are located in the Powerhouse building that provided steam for the Facility. These boilers were installed in 1941 and overhauled in the 1980s, but the . burners were replaced with units that did not increase the emissions rates (per .
> - · The boilers are equipped with electrostatic precipitating systems (ESPs) and use a common exhaust stack. Boiler #1 was no longer operational and the Title V Permit Renewal Application stated it should be removed from the future permit. According to
> - · all of the boilers bum coal as the primary fuel, and use fuel oil as backup and when significant loading changes occur. Discussion of the review of records related to these boilers is provided in the subsection below.
> reported that low Sulfur coal (below 1%) cannot be used in the boilers because it reduces the efficiency of the ESPs. Based on the coal analyses that accompany every shipment provided by - · Powerhouse Engineer, at the time of the inspection, the sulfur content varied from between 1.2 and 1.35 percent.

ATSDR Response: ATSDR had a copy of the Multi-Media Inspection Report and considered it in preparing the draft health consultation. It does not contain any environmental sampling data relevant to the health consultation's focus. The reference has been added to the Section entitled "References Reviewed But Not Cited."

PC1-6: In point of fact, at a U.S. Army/BAE Systems public meeting on May 8, 2014, our community was told that the OBG was used 233 times in 2013, a significant source of toxic PM exposure that ought to be included in this ATSDR evaluation.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC1-7: The OBG is located 100 feet from the New River and the Virginia Department of Mines and Minerals map shows the presence of sinkholes beneath the OBG site. http://www.dmme.virginia.gov/commercedocs/OFR_09_01.pdf

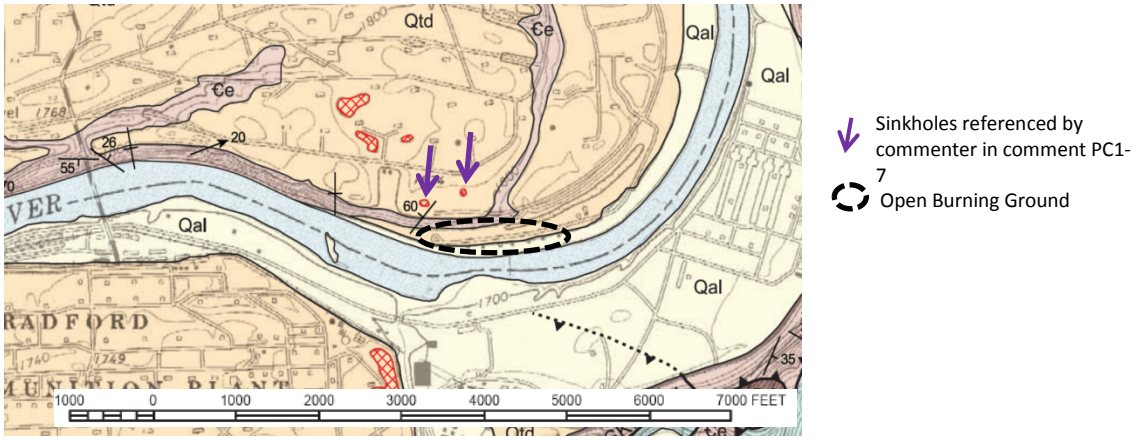
[The map is very large and reproducing it for this Appendix is not feasible [105][3]; the relevant portion of the map is shown in Figure E-2 on the following page.]

[3] Schultz, Arthur P., and Bartholomew, Mervin J., 2009, Geologic Map of the Radford North quadrangle, Virginia: Virginia Division of Geology and Mineral Resources Open File Report 09-01, 1:24,000-scale geologic map.

ATSDR Response: ATSDR contacted Arthur Schultz of the U.S. Geological Survey, one of the authors of the map referenced. He stated that he prepared a map of sinkholes in 1979 or 1980 by filling in circular, closed contours shown on topographic map data existing at that time. He stated that he did not perform field confirmation of the sinkholes. He also stated that in some instances, he did not mark as sinkholes closed contours he felt were obviously man-made features. The Open-File Report map is a 2009 update digitizing the data and modernizing the text [personal communication, Arthur Schulz, U.S. Geological Survey, June 9, 2014].

Figure E-2 indicates that the sinkholes referenced by the commenter are not at the Open Burning Ground. The Open Burning Ground is underlain by a 13 to 20-foot thick alluvial deposit of clay and silt overlying sand and gravel; this alluvial deposit appears to be laterally continuous across most of the site [104].[4] The alluvium is underlain by bedrock of the Elbrook Formation, which can exhibit karst features. Groundwater beneath the Open Burning Ground has been consistently measured to flow towards the New River[9,5] [104,93-96], so groundwater flow through sinkholes would discharge to the river.

Figure E-2. Illustration supporting ATSDR response to Public Comment PC1-7. Modified from [105, footnote 3].

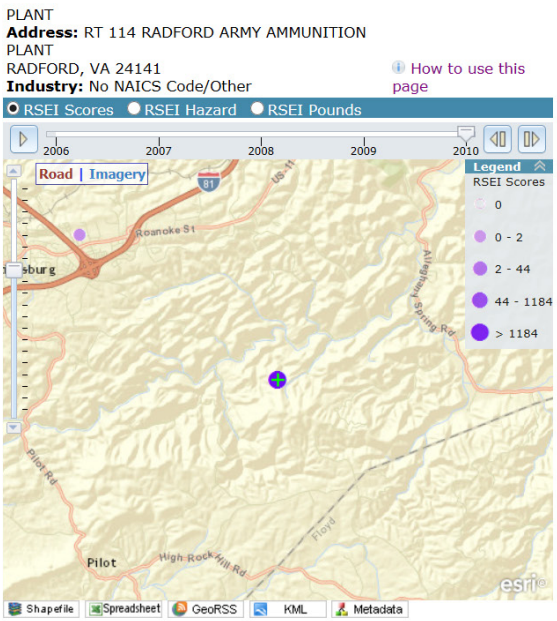


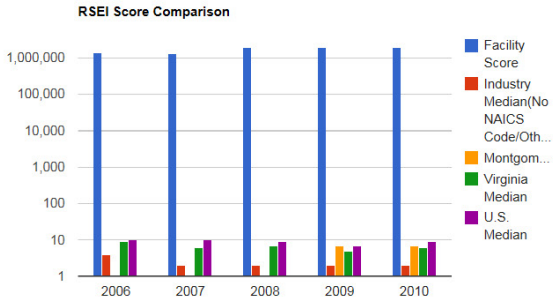
PC1-8: The EPA's own "Right-to-Know" data based on the TRI notes the relative health risk for people living around RAAP is **five orders of magnitude** higher than it is at similar chemical manufacturing facilities nationwide. We request that the ATSDR coordinate with the EPA to make use of TRI data for this health risk assessment. Please see the EPA graph of our risk, which does not include emissions from the OBG because they are not reported on the TRI: http://oaspub.epa.gov/enviro/rsei.html?facid=24141SDDSRPOBOX [Screen shot of graph this links to is shown in Figure E-3 below]

[4] Virginia Department of Environmental Quality. Permit for the Treatment of Hazardous Waste by Open Burning, United States Amy (Owner), BAE Systems Ordnance Systems Inc. (Operator), Radford Army Ammunition Plant, State Route 114, Radford, Virginia 24141, EPA ID No. VA1210020730. Provided electronically via 5 emails from Ashby Scott of VDEQ to Jill Dyken of ATSDR on August 26, 2014.

[5] Draper Aden Associates. Annual Groundwater Monitoring Reports, Open Burning Ground (Hazardous Waste Management Unit 13). Reports from 2009-2013.

Figure E-3. Screen shot of graph for link above in public comment PC1-8.





Year	Facility Score	Industry Median (No NAICS Code/Other)	County Median	State Median	U.S. Median
2006	1,388,055	4	0	9	10
2007	1,295,396	2	1	6	10
2008	1,885,877	2	0	7	9
2009	1,892,670	2	7	5	7
2010	1,877,573	2	7	6	9

ATSDR Response: As was described in the draft health consultation, the Toxic Release Inventory (TRI) is a summary of monthly data reported by the facility as part of its Virginia Pollutant Discharge Elimination System (VPDES) and state air permit requirements. ATSDR used the VPDES monthly surface water release data in evaluating potential exposures from RFAAP. TRI air data were not used because the focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC 1-9: The map on page 7 [Figure 3] of the ATSDR draft estimating the number of private drinking water wells is not representative of reality. Water Authority reports have indicated there are over 150 private drinking water wells in this "target zone." Furthermore, a call to Bob Fronk, Director of the Montgomery County PSA, in April of 2014, confirmed there are two municipal wells to supplying the Riner/Woodview PSA system, not zero as stated in the draft assessment. The 2012 Consumer Confidence Report for this PSA system also clearly notes wells are the source water: http://www.montgomerycountyva.gov/filestorage/1146/98/173/698/1920/CCR_woodview_2012.pdf

ATSDR Response: As stated in the caption for Figure 3, "Green dots labeled "private wells" were identified from a historical database (from the 1990s) and may not be used today; also, many more wells could exist now." The caption notes that the cross hatched area indicates the area not on public water and therefore where residents probably use private wells. The inclusion

of the actual number of private wells does not change the conclusions and recommendations of the health consultation.

The health consultation focused on the Prices Fork/ Merrimac subsystem of Montgomery County's Public Service Authority (PSA), at that time supplied by water from RFAAP, since that was the main concern stated to us by community members. Riner is located several miles south of RFAAP. Any public wells serving that community would not be affected by RFAAP, for the same reasons we found private wells are not affected.

PC1-10: The people living around the Radford Army Ammunition Plant, who have only private wells to drink from and no other source of air to breathe, humbly request a more thorough risk assessment. Dr. Dyken informed me that the Department of Defense paid for this health consultation, which is troubling given their role as employers of the contractors who are creating the toxins we are being exposed to around this Federal Facility. Please explain how scientific rigor and objectivity is maintained under this funding arrangement, which seems to put the fox in charge of counting the sick and dead hens.

ATSDR Response: ATSDR is an independent agency in the Department of Health and Human Services. We conducted this study using our Agency's standard procedures. The final conclusions and recommendations are those of ATSDR.

ATSDR was set up by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This legislation authorized EPA to recover money spent on cleaning up sites, and money spent by ATSDR to carry out its public health responsibilities, from potentially responsible parties. The law was amended to clarify that federal facilities are subject to the same requirements of CERCLA as other sites, including the liability and enforcement provisions of the law [105].[6] *ATSDR's health assessment activities at federal sites are funded through negotiated agreements with the Department of Defense (or the Department of Energy, as appropriate). ATSDR reports progress on planned activities and accepts comments from these federal agencies, similar to the public and other agencies we work with.*

PC1-11: Finally, the geographic location of the Main Manufacturing Area at RAAP and subsequent exposure areas is in fact Pulaski and Montgomery Counties, not the City of Radford. Belview Elementary School, where the ATSDR community meetings took place, is located in Montgomery County, despite having a Radford mailing address. An informal survey of nearby residents indicates they *do not* consider themselves to be Radford residents, but rather tax paying citizens who vote in Montgomery County, Virginia.

ATSDR Response: The health consultation evaluated exposures for all the areas around RFAAP, not just Radford. In the draft health consultation, ATSDR stated that the Main Manufacturing Area was near the city of Radford and described the facility as encompassing Montgomery and Pulaski counties. The Facility's Radford mailing address listed on the cover page is how the site is listed in EPA databases used for facility identification.

[6] Bearden DM. Comprehensive Environmental Response, Compensation, and Liability Act: A Summary of Superfund Cleanup Authorities and Related Provisions of the Act. Congressional Research Service. Washington (DC): June 2012. Accessed online on August 20, 2014 at: http://fas.org/sgp/crs/misc/R41039.pdf.

PC1-12: Please afford our community the due diligence required to evaluate the integrity and completeness of the draft assessment for our potential exposure from the Radford Army Ammunition Plant. If the ATSDR did not intend to make an official assertion that our water is not tainted by RAAP, please clarify that with the press and ask for a published correction. http://www.roanoke.com/news/local/radford/water-not-tainted-by-radford-army-ammunition-plant-study-says/article_99032408-cb59-11e3-a6f9-001a4bcf6878.html

ATSDR Response: The newspaper article cited was correct in stating ATSDR's conclusion that drinking water in the area is not affected by RFAAP.

PC1-13: As a representative of many of the people impacted by the important work of ATSDR, I sincerely hope perchlorate and the OBG emissions will be included in your scientific analysis before a final assessment is issued for this site.

ATSDR Response: This health consultation's focus was on groundwater and surface water releases and their potential impact on drinking water. Perchlorate was noted to be present in site groundwater above drinking water comparison values, as indicated in both Table 2 and Table A.2b of the health consultation. However, ATSDR's evaluation concluded that site groundwater would be discharged eventually into the New River before ever reaching private wells in the area.

ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

Comments from Public Commenter #2 (PC2):

PC2-1: As a member of the Environmental Patriots of the New River Valley I am very concerned about the air and water pollution that seems to be coming from the Radford Army Ammunition Plant and the related health problems and risks.

I urge the ATSDR seriously consider the data and information provided to you by [a private citizen]. She has done extensive study and research about the health risks to the residents of Montgomery, Pulaski and Giles counties.

ATSDR Response: ATSDR received comments from the private citizen mentioned; they are included in this Appendix along with responses.

PC2-2: I also urge you to see that proper and extensive testing is done and done in labs that meet EPA standards and by EPA certified persons. If proper testing does show the arsenal polluting our water and air then I expect those in power to make changes and corrections and to do so as soon as possible.

ATSDR Response: ATSDR evaluated extensive environmental sampling available for groundwater and surface water releases from RFAAP. The available data were of acceptable quality for the evaluation we performed.

The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC2-3: We have more than the average number of illnesses and cancer which is very possibly related to the arsenal emissions and open air burning. We, as a country, owe our citizens proper attention and investigation into pollutants coming from the Radford Army Ammunition Plant.

ATSDR Response: ATSDR's site specific evaluations focus on assessing exposure and whether exposures are high enough to increase the risk of harmful health effects. This is because many factors can influence the rates of cancer and other diseases. ATSDR's health consultation found that potential exposures to contaminants released from RFAAP into groundwater or surface water are unlikely to harm people's health through their drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

Comments from Public Commenter #3 (PC3):

PC3-1: Those of us who use public or well water in the New River Valley or breathe the air worry our health may be compromised by the Radford Army Ammunition Plant in Pulaski and Montgomery Counties (not Radford, as indicated at the link by the Virginia Department of Environmental Quality: cities are independent in Virginia.)

ATSDR Response: ATSDR's health consultation found that potential exposures to contaminants released from RFAAP into groundwater or surface water are unlikely to harm people's health through their drinking water. Several state and federal databases list RFAAP by its mailing address in Radford. ATSDR attempted to explain the location of RFAAP and surrounding potentially impacted communities throughout the health consultation. The health consultation evaluates exposures for all the areas around RFAAP, not just Radford.

PC3-2: Despite Army's plan to clean up the plant, it operates open burning grounds and dumping into the New River in karst terrain. EPA issued a unique permit as a way to protect the economic development of the facility instead of the Superfund permit warranted by the EPA's own investigation.

ATSDR Response: The comment is noted. RFAAP is a large, complex, operating facility and falls under regulatory authority of several different programs.

PC3-3: We shouldn't have to choose between jobs and health and need the CDC to improve the current consultation so that we gain knowledge of the possible health effects. It is not sufficient to let the Department of Defense conduct the study and omit data relevant to exposure risk.

ATSDR Response: ATSDR conducted this evaluation using our Agency's standard procedures. The final conclusions and recommendations are those of ATSDR. As described in the response to public comment PC1-10, potentially responsible parties, including federal agencies, are responsible for repaying the money spent by ATSDR to carry out its public health responsibilities. This health consultation was funded through a general negotiated agreement with the Department of Defense covering most of the DOD sites ATSDR is currently working on.

PC3-4: We need testing of all drinking water wells (both the 180 private and 2 public wells) in the impact zone. The EPA called for this thorough, extensive testing of all DW wells within a two mile radius of EACH contaminated site in 1992, but that testing was never done. The EPA Deficiency Report for the Hazard Rating Score assigned to RAAP in 1992 makes clear that their risk assessors considered this testing essential to an honest characterization of the risk we face from RAAP.

ATSDR Response: Reference [18] in the draft health consultation lists responses to the HRS Deficiency Report and provides data on drinking water wells within a two mile radius of three different points on the facility. These data were summarized by ATSDR and presented in Table 6 of the draft health consultation.

ATSDR's evaluation concluded that drinking water in the vicinity of RFAAP is not affected by facility releases to groundwater and surface water.

PC3-5: Please afford us the testing and complete risk assessment that was called for by EPA over two decades ago and is now warranted given the detection of perchlorate in wells off site of the facility. Independent testing by an EPA certified lab is the only way for your agency to conclude with certainty that perchlorate and other contaminants unique to RAAP have not migrated through the Karst terrain.

ATSDR Response: The detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[7] *ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River.*

[7] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

A peer-reviewed journal article discusses a survey of perchlorate in groundwater at "pristine" sites in the United States [107].[8] The authors report perchlorate levels in groundwater samples collected from 326 domestic, agricultural, and recreational wells across the United States. Care was taken to avoid documented sites of perchlorate use or release or perchlorate contamination due to disinfection using hypochlorite. The majority of samples were lower than detection and reporting limits (0.04 micrograms per liter and 0.12 micrograms per liter, respectively), but 109 samples contained quantifiable perchlorate less than 1.0 micrograms per liter, and 28 samples had perchlorate ranging from 1 to 10.4 micrograms per liter. The sources of perchlorate in these "pristine" samples is not known, but possible explanations include historical use of Chilean nitrate as an agricultural fertilizer (Chilean nitrate contains perchlorate), or formation from natural atmospheric processes, such as reaction of chlorine-oxygen radicals with sulfuric acid aerosols, electrical discharge through chloride aerosol, reaction of aqueous chloride with high concentrations of ozone, and direct photolysis of aqueous chlorite [100].[9] This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing.

PC3-6: While perchlorate can disrupt the thyroid's ability to produce hormones needed for normal growth and development, it is still unregulated by the EPA. The industry (including Aerojet, American Pacific Corporation, ATK and Lockheed Martin) works "cooperatively" with the U.S. Environmental Protection Agency to try to convince it to keep the chemical unregulated, which in an Orwellian twist it calls increasing "scientific and medical understanding of perchlorate's risk to human health." In addition, it has a website disingenuously called the Perchlorate Information Center to convince the public that perchlorate is not an endocrine disruptor.

ATSDR Response: ATSDR is an advisory agency and has no regulatory authority. The following information on perchlorate is from EPA sources and provided for the reader's information. In 2011, EPA published its final regulatory determination on perchlorate in which it decided to regulate perchlorate under the Safe Drinking Water Act [108].[10] This action reversed a 2008 preliminary determination. According to the EPA's website on perchlorate in drinking water (http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm), the regulatory determination initiates a process to develop and establish a national primary drinking water regulation. The website states that perchlorate "can disrupt the thyroid's ability to produce hormones needed for normal growth and development." As of the writing of this report (August 2014), the process for developing and evaluating the proposed rule is ongoing. The proposed rule has not yet been published for public review and comment.

PC3-7: We also need an independent study of air and soil pollution. To say that the data doesn't exist means the data needs to be collected.

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[8] Parker DR, Seyfferth AL, Reese BK. Perchlorate in Groundwater: A Synoptic Survey of "Pristine" Sites in the Coterminous United States. Environmental Science and Technology 2008; 42(5): 14651471. Supporting information accessed at http://pubs.acs.org.

[9] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Perchlorates.

[10] U.S. Environmental Protection Agency. 2011. Drinking Water: Regulatory Determination on Perchlorate. Federal Register 2011 February 11;76:7762-7767.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

Results from soil sampling on the site are available, but the community does not have access to the site and cannot come into contact with soil there.

PC3-8: I could go on in further detail but time is short until the deadline. While I would like the deadline extended I want to submit something tonight. Let me just add that I have read and support the comments of [two other members] of the New River Valley Environmental Patriots.

ATSDR Response: ATSDR received comments from the private citizens mentioned; they are included in this Appendix along with responses.

PC3-9: It's time for some environmental justice here in Appalachia. We too often hear that it's jobs OR health, a choice that we shouldn't have to make. I've written before on the rhetoric of the coal industry and the so-called War on Coal. It appears that what President Eisenhower called the military-industrial complex is using the same arguments and the EPA took its marching orders. Isn't it time for them to reverse course and shouldn't the Center for Disease Control be helping us provide data on what is at stake for us and our children and generations to come. Thank you for your assistance in this matter.

ATSDR Response: ATSDR has limited capacity to conduct environmental sampling and usually relies on data collected by other organizations or agencies. The data evaluated in this health consultation did not indicate that environmental contamination released by RFAAP into groundwater or surface water could affect drinking water in the area. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

Comments from Public Commenter #4 (PC4):

PC4-1: I would like to submit the following Comments for the ATDSR 2014 Radford Army Ammunition Plant Health Consultation. I would like all of my comments to be included in their entirety as dictated by federal law. This is notification of formal submission of the following public comments for the Health Consultation Evaluation of Potential for Chemicals Released to Groundwater or Surface Water to Affect Drinking Water In Nearby Community of the Radford Army Ammunition Plant Radford Virginia EPA Facility ID: VA1210020730

ATSDR Response: The comments are included in their entirety; however, as noted above, personal identifying information has been removed; this is indicated by inserted bracketed text in

a different font. Also, the comments were split and numbered by ATSDR into specific comments that were responded to individually, and (if needed) we corrected obvious typographical errors and made font changes to make the comments more readable and consistent throughout.

PC4-2: Comment#1
The demographic profile of the unincorporated low-income communities immediately surrounding the Radford Arsenal fit the definition of an environmental justice community of concern. The ATDSR report fails to take into consideration the Environmental Justice implications of the either the well documented contamination or the routine activities at RFAAP. The Executive Order 12898 signed by President Clinton in 1994 directs federal agencies to do the following:

"To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands."

The ATSDR Report has made NO attempt to account for the environmental justice implications of well documented contamination RFAAP. Given that RFAAP is the largest toxics emitter in Virginia and the second largest toxics emitter IN ALL OF THE UNITED STATES and is directly adjacent to human populated areas with no significant buffer zone this neglect of environmental justice implications is both unacceptable and direct threat to democracy. I request that a more adequate study be conducted.

ATSDR Response: ATSDR recognizes that the community surrounding RFAAP may bear a greater burden of environmental contamination than other communities. ATSDR agrees that reducing contamination in the environment would benefit all and is committed to involving local communities in our processes to determine effects of environmental contamination on public health.

We took the following actions to support and abide by Executive Order 12898 while conducting this evaluation for the community surrounding RFAAP:

- *We assessed the community's request to evaluate potential exposures to contaminants from the RFAAP facility and determined that a health consultation was an appropriate response to the concerns that were raised.*
- *We communicated with the community to ensure we adequately understood their concerns; and we accepted the petition by community members to assess whether contamination released from RFAAP is affecting drinking water in the area.*
- *We gave local residents a role in ATSDR's process by listening and incorporating their concerns and suggestions into the health consultation process.*

- *We involved local community members, environmental groups and their leaders throughout ATSDR's health consultation process by holding multiple conference calls and in person meetings.*
- *We discussed with community members and local environmental organizations ATSDR's data needs and included environmental data collected by a local environmental group in our evaluation.*
- *We were available at the public availability session and by e-mail and phone to answer questions from the community about ATSDR's work.*
- *We informed residents of our findings using several different communication methods to meet the needs of various community members.*

ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-3: Comment #2
The report claims "It is physically impossible for substances released to move upstream against the flow of the New River…" This conclusion is unacceptable considering fluid mechanics of a diffusion gradient through a porous medium in the ground water under the plant. However the surrounding area and the facility sit directly upon Karst topography with multiple sink holes identified in the Virginia Department of Mines and Minerals map under the facility and specifically the open burning ground. The fluid dynamics and mechanics of a diffusion flow process in a porous medium dictates that diffusion can occur against the force of gravity. Therefore, the assumption that toxic groundwater contaminants identified on pages 63-70 of the report is moving only in the flow of gravity with the river is not supported by existing scientific research. In light of the major scientific shortcomings of the ATDSR report, request that another risk assessment study be conducted on RFAAP.

ATSDR Response: Two forces act on contaminants in the environment: advection and diffusion. Advection refers to transport with the mean fluid flow. Diffusion refers to transport of compounds through random motion. The interaction of these two forces determine the overall direction of contaminant transport. Even in slow-moving groundwater systems (such as porous, unconsolidated sediment), the rate of advection is much greater than that of diffusion, so upgradient diffusion is negligible. Advection in karst geology is typically much greater than in unconsolidated sediment.

Groundwater at RFAAP has been contaminated at several sites, and diffusion and groundwater flow have influenced the extent of contaminant plumes. These plumes of contaminated groundwater are measured and monitored regularly. At RFAAP, the overall groundwater flow (theoretically and as measured in dye trace studies) is towards the New River. If any contamination in the groundwater reaches a spring or other outlet on this large-flow river, it will flow with the river downstream, not upstream, because the advective force of the river water is much, much larger than any diffusive forces acting on contaminants. Mixing in the river due to turbulence and diffusion will then result in the contaminant being diluted by the river's flow.

PC4-4: Comment # 3
RFAAP has already been designated as meeting criteria for Superfund Listing. The RFAAP needs to be placed on EPA's National Priorities List and categorized as a Superfund Site. The best way to ensure healthy democratic public oversight of remediation efforts at the many dangerously contaminated sites at the Radford Arsenal is to list the site as a Superfund. The current remediation program has failed miserably and should be discontinued and replaced with a strong Superfund monitoring, remediation, and public participation program. Instead of serving democracy and protecting public health, RFAAP has chosen to sacrifice local health and local democratic integrity in the name of corporate profits. This is patently unacceptable in a liberal democracy like the United States.

ATSDR Response: Listing a site on the National Priorities List (NPL) is the decision of the U.S. Environmental Protection Agency (EPA), not ATSDR. The Department of Defense leads RFAAP's investigation and cleanup of sites, but this work is guided by both CERCLA and RCRA and is overseen by EPA and by VDEQ [105].[11] *EPA's RFAAP website lists contacts for the Corrective Action Program as Erich Weissbart from EPA Region 3 (weissbart.erich@epa.gov) and Jim Cutler from VDEQ (jcutler@deg.virginia.gov).*[12] *Public input is part of the Installation Restoration Program's process, with opportunities for public comment and public participation on the Restoration Advisory Board.*[13]

PC4-5: Comment #4
Perchlorate is a primary ingredient in rocket fuel and is used extensively at the RFAAP site for both Fireworks and Ammunitions production. Anyone with basic common sense--and anyone who is aware of the perchlorate that has been documented in multiple wells in and around the RFAAP site--can assume that perchlorate migrates from the RFAAP site and enters local air and water during open burning and other controlled and uncontrolled releases. There is a very high incidence of thyroid disease and thyroid cancer in the New River Valley. Perchlorate has been scientifically linked to disruption of thyroid function. Given this scientifically documented information, an official epidemiological study of the communities directly impacted by RFAAP must be conducted to ascertain what, if any possible roles RFAAP may be playing in the elevated rates of thyroid disease in this area.

ATSDR Response: ATSDR's site specific evaluations focus on assessing exposure and whether exposures are high enough to increase the risk of harmful health effects. This is because many factors can influence the rates of cancer and other diseases. The draft health consultation concluded that contaminants in groundwater or surface water released from RFAAP would not affect private wells in the area. Because the evaluation did not identify a completed exposure pathway, this evaluation did not meet ATSDR's criteria for performing a review of health outcome data as part of the consultation [25].[14]

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[11] Bearden DM. Comprehensive Environmental Response, Compensation, and Liability Act: A Summary of Superfund Cleanup Authorities and Related Provisions of the Act. Congressional Research Service. Washington (DC): June 2012. Accessed online on August 20, 2014 at: http://fas.org/sgp/crs/misc/R41039.pdf.

[12] http://www.epa.gov/reg3wcmd/ca/va/webpages/va1210020730.html

[13] http://www.radfordaapirp.org/comminv.htm

[14] Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (Update). Atlanta, GA: Department of Health and Human Services; January 2005.

The recent detections of perchlorate in offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[15] *Exposure to this level of perchlorate would not be expected to result in any harm to health. Perchlorate is an important propellant because is decomposes rapidly to the gaseous products water, hydrochloric acid, nitrogen and oxygen, leaving no residue [109].*[16] *Waste materials containing perchlorate are expected to burn efficiently. Unburned material, possibly containing perchlorate, would remain with the ash residue on the burn pan [110].*[17]

PC4-6: Comment #5
The community requested that air, land, and water, be included in this study and yet ATDSR decided to only examine very limited groundwater data. Air pollution from RFAAP--especially fallout from the Open Burning Ground--is impacting all local communities in this area, including Blacksburg and Virginia Tech. People who go tubing, fishing, and boating on the New River around the Arsenal are being exposed to cancer-causing and endocrine-disrupting toxic chemicals without their knowledge or consent. This is shameful and intolerable on the part of RFAAP. It was very irresponsible of ATSDR to conduct a study with such flagrant data omissions. The multi-media pollution fallout from RFAAP poses major environmental health issues and the lack of accountability for this toxic fallout poses a major threat to the integrity of liberal democratic governance not only in the New River Valley but in the U.S. at large. Given the shortcomings of this study and RFAAP's horrific historical record of public engagement, another more sufficiently robust health study of communities impacted by RFAAP is clearly warranted.

ATSDR Response: ATSDR's site specific evaluations focus on assessing exposure and whether exposures are high enough to increase the risk of harmful health effects. This is because many factors can influence the rates of cancer and other diseases.

The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report. Results from soil sampling on the site are available, but the community does not have access to the site and cannot come into contact with soil there, so no exposure is possible.

PC4-7: Comment #6

[15] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.
[16] Brown GM and Gu B. 2006. The Chemistry of Perchlorate in the Environment. In: Gu B, Coates JD (eds.) Perchlorate: Environmental Occurrence, Interactions and Treatment. Springer US, DOI 10.1007/0-387-31113-0.
[17] Trumpolt CW, Crain M, Cullison GD, Flanagan SJP, Siegel L, Lathrop S. Perchlorate: Sources, Uses, and Occurrences in the Environment. Remediation 2005; Winter: 65-89.

Given the data we already have about the nature of the chemicals produced and/or used at RFAAP, as well as modes of production currently utilized at the facility, common sense would indicate that on-site workers at RFAAP are likely receiving some of the heaviest toxic chemical burdens experienced in all of the United States. Given the demographics of the labor force at RFAAP, this constitutes a major environmental justice issue. I would like to formally request ATSDR to include occupational health impacts in their next RFAAP study and investigate possible relationships between illness occurrence among RFAAP workers and illness occurrence among the communities surrounding RFAAP. I urge ATSDR and/or any other responsible agencies to please get these epidemiological studies under way. People have a right to know what they are being exposed to and how those chemicals are impacting their working and residential communities.

ATSDR Response: ATSDR does not evaluate worker exposures. The U.S. Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) are the federal agencies responsible for worker exposure issues.

OSHA makes and enforces regulations to ensure working conditions are safe and healthful. Workers can contact OSHA with questions or complaints about hazards at their workplace. See https://www.osha.gov/workers.html for more information.

NIOSH is a federal advisory agency that conducts research and makes recommendations for preventing worker injury and illness. Workers can contact NIOSH and request a Health Hazard Evaluation to study whether they are exposed to hazardous materials or harmful conditions. See http://www.cdc.gov/niosh/hhe/HHEprogram.html for more information.

PC4-8: Comment #7
I am deeply concerned for the people that live in our area because the Radford Army Ammunition Plant Assessment did not include test results from the U.S. Army in 2010, confirming that ground water at 16 of 16 test wells across the Main Manufacturing Area (MMA) have significant perchlorate contamination. The sinkholes at the Open Burning Ground (OBG) and other places in the MMA where the perchlorate persists to this day present constitute an identified point source for cross-contamination through the Karst features beneath all of the MMA. Numerous sinkholes identified by the Virginia Dept. Of Mines & Minerals confirms their potential to serve as conduits for toxins to travel into wells off site. These documented sinkholes in the MMA, including those beneath the Open Burning Ground where perchlorate may have been a component in each of the 233 open burns conducted last year alone, are the "smoking gun" that ought to compel ATSDR to require additional well testing.

The widespread perchlorate contamination in soil, surface and groundwater, at RAAP according to the U.S. Army and results from private contractors at RAAP over decades, are facts that cry out for a more thorough risk assessment to safeguard our community.

ATSDR Response: Please see responses to public comments PC1-1 and PC1-7. The draft health consultation included data from original RFAAP reports which were summarized by another group in fact sheets referenced in PC1-1 and restated by this commenter. The draft health consultation recognized that perchlorate in groundwater at some sites on RFAAP was present at

concentrations higher than health-based drinking water screening values. However, the evaluation concluded that all groundwater at the site would reach outlets at the New River before encountering any private wells. Groundwater on the opposite side of the New River would also flow towards the river. Sinkholes identified in the Virginia Department of Mines and Minerals open file report were not located at the open burning ground. Sinkholes could exist in the area; but flow through sinkholes would also lead to outlets on the New River, where any contaminants would be quickly diluted.

PC4-9: Clearly, the ongoing contamination of groundwater, soil and surface waters by disposal of waste from Grucci Fireworks at the OBG makes the presence of perchlorate in 4 of 5 wells tested by the Sierra Club a significant finding. It is highly unlikely that the private wells tested were contaminated with perchlorate from any source other than the operations at RAAP. A more sensitive test to differentiate whether it is ammonium perchlorate in these private wells would help to delineate the point source. The data are clear and it seems only prudent and in the interest of public safety to recommend that all municipal and private wells in the areas surrounding RAAP be tested to confirm or disprove cross-contamination from RAAP.

ATSDR Response: The draft health consultation concluded that groundwater or surface water releases from RFAAP would not affect private wells in the area. The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[18] ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River. The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in these wells is below health-based screening levels and within the range of perchlorate found in a survey of "pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.

Ammonium perchlorate is highly soluble and dissociates in water to form ammonium and perchlorate ions. While perchlorate is persistent, ammonium could be biodegraded over time. Testing for ammonium perchlorate, unless the concentrations were very high, would not necessarily indicate the original source of the perchlorate [111].[19] Some isotope-based methods have been proposed to differentiate natural perchlorate from man-made perchlorate, but these

[18] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

[19] Urbansky, ET. Perchlorate Chemistry: Implications for Analysis and Remediation. CRC Pres LLC. 1998. Accessed online on August 20, 2014 at: http://clu-in.org/download/contaminantfocus/perchlorate/urbansky2.pdf.

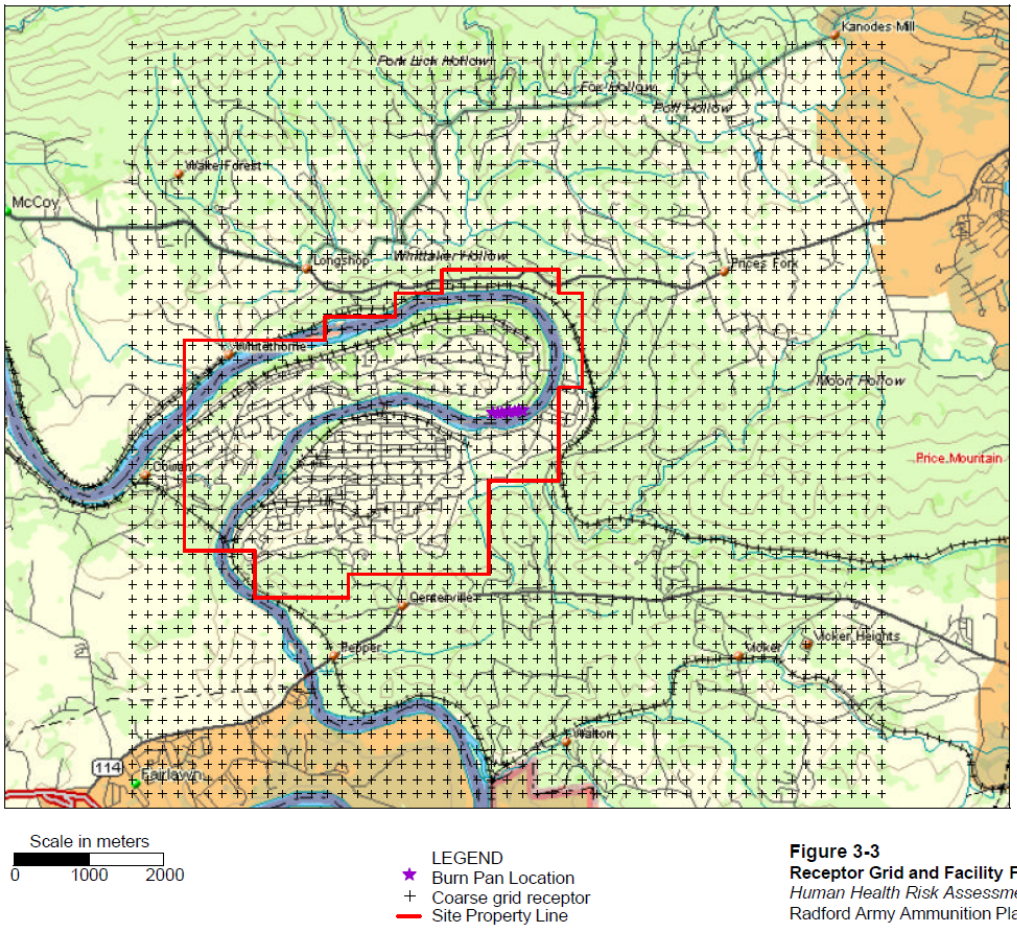
have not been fully tested, may not be able to unambiguously determine the original source, and may not be usable for samples with low perchlorate concentrations [110].[20]

PC4-10: The Federal Facility which is the source of the contamination has a moral, if not legal, obligation to pay for the testing that will ensure citizens are not subject to drinking their toxic waste as disposed of by open burning to the air we breathe and ultimately "rains out" and into the water our children drink. Please see maps from the HHRA of 2005 illustrating the dispersal pattern and reason for our concern. The EPA document on perchlorate as an "emerging contaminant" discusses dispersal through soil and substantiates the likelihood that the perchlorate found in 80% of wells tested around RAAP last year is coming from the production and disposal at the facility.

[Note Figure 3-3 from CH2MHill's Human Health Risk Assessment [101][21] is copied in Figure E-4 below. This figure was not attached by any of the commenters; we presumed this is the figure mentioned based on the comment.]

[20] Trumpolt CW, Crain M, Cullison GD, Flanagan SJP, Siegel L, Lathrop S. Perchlorate: Sources, Uses, and Occurrences in the Environment. Remediation 2005; Winter: 65-89.
[21] CH2MHill. Human Health Risk Assessment for the Open Burning Ground, Radford Army Ammunition Plant. Prepared for Alliant Ammunition and Powder Company, LLC. Dayton (OH): September 2005.

Figure E-4. jpg file of Figure 3-3 from Human Health Risk Assessment, presumed to be referenced in public comment PC4-10.



ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-11: The findings of CH2MHill in their 2005 assessment of the Open Burning Ground performed for Alliant Techsystems included maps of contaminant distribution which have been attached to comments submitted by others. [again, presumed to be the figure shown in E-4 above] Perchlorate is known to readily leach from the soil where it falls after each burn. As this and other toxins become part of the GW recharge in this Karst aquifer, the potential for widespread diffusion into wells outside of the RAAP boundary is very real.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at

existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-12: Please note that the CH2MHill study of the OBG indicates "special receptors" for the particulate matter which are upstream of the intake for the Blacksburg/Christiansburg/VPI Water Authority in addition to numerous points on the river downstream of the OBG.(see River Receptors map). The combination of air dispersal over a wide area and direct deposition into the New River, which serves as a source of drinking water and recreational fishing, is of great concern to our community, especially those using wells and municipal water. (see Receptor Grid map).

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-13: The source of perchlorate already found in four private wells is likely to be the Radford Arsenal, which can be confirmed with more extensive and accurate testing. Please note the EPA guidance document attached to comments submitted by others which confirms how perchlorate moves in soil, the association of perchlorate with the production that has taken place at RAAP since 1941 and most importantly, the importance of this ongoing source of perchlorate, barium, aluminum, chromium and other toxins being emitted from the "skid burns" at the Open Burning Ground. It is incumbent upon your agency to assess our risk to exposure through air and the migration of GW off site of the Arsenal. The tests cited in your report confirming perchlorate in 4 of 5 wells tested simply cannot be ruled out as coming from the documented point sources at RAAP without more testing and analysis.

ATSDR Response: The draft health consultation concluded that groundwater or surface water releases from RFAAP would not affect private wells in the area. The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[22] *ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River. The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in these wells is below health-based screening levels and within the range of perchlorate found in a survey of*

[22] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

"pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.

PC4-14: Therefore, we implore your agency to recommend testing of all drinking water wells within a three mile radius of the MMA boundary to rule out this route of exposure. The community in this "impact zone," cannot and ought not be asked to bear the financial burden to test for contaminants from the production and waste disposal processes at RAAP. The Dinitrotoluene isomers, chromium other chemicals included in the permit for the OBG at RAAP are specific to their production and unlikely to have any other source - agricultural or otherwise.

ATSDR Response: ATSDR's evaluation showed that private wells are not affected by groundwater or surface water releases from RFAAP, and therefore we do not recommend testing for chemicals specific to the arsenal. ATSDR's recommendation to private well owners for water testing was for general water quality such as offered through county testing programs.

PC4-15: The EPA called for this thorough, extensive testing of all DW wells within a two mile radius of EACH contaminated site in 1992, but that testing was never done. The EPA Deficiency Report for the Hazard Rating Score assigned to RAAP in 1992 makes clear that their risk assessors considered this testing essential to an honest characterization of the risk we face from RAAP. Please afford us the testing and complete risk assessment that was called for by EPA over two decades ago and is now warranted given the detection of perchlorate in wells off site of the facility. Independent testing by an EPA certified lab is the only way for your agency to conclude with certainty that perchlorate and other contaminants unique to RAAP have not migrated through the Karst terrain into the 180 plus private and two municipal wells in the exposure zone shown on the maps from the CH2MHill Risk Assessment of 2005.

ATSDR Response: The referenced "Deficiency Report" (reference [18] in the draft health consultation) does contain a request for private well testing data, but did not specify components to be tested, and it is not clear whether the facility was to do the testing or merely report available test results. The facility did provide some private well data, and the results were summarized in the health consultation in Table 6, Summary of Historical Sampling Results From Private Wells Near Radford Army Ammunition Plant, and discussed in the text.

PC4-16: Money should not be an issue for this Federal Facility to fund the widespread testing required at this site. The private contractor operating the facility, BAE Systems, along with the Department of Defense, who owns the facility and paid for this assessment, have the resources at their disposal to finance the testing that will rule out a clear and present threat to the health and safety of our children who drink water and breathe air every day that may be contaminated with the endocrine-disrupting chemical, perchlorate and other RAAP generated toxins.

ATSDR Response: The comment is noted. ATSDR's evaluation concluded that contaminants released from RFAAP into groundwater and surface water are not affecting either public water supplies or private wells in the area. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the

community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-17: Just think what that public money could do to ensure public safety by testing the water and ambient air quality. I do not believe our tax dollars should be spent for water treatment plants in foreign lands while neglecting to provide for homeland security by protecting this Appalachian community from the environmental impact of munitions and fireworks production at RAAP.

ATSDR Response: The comment is noted. ATSDR does not have authority to set funding priorities of other agencies.

PC4-18: It is unconscionable for our military and enormous pentagon budget to be directed outside of America while at the same time we are not testing water quality and air quality beyond the Arsenal boundary, manufacturing both critical weapons for soldiers as well as fireworks and ammunition being produced solely for the private market. We ask for due diligence and the DoD funding for this assessment to be extended to protect the health and safety of our community around the Arsenal, both workers and families subjected to daily toxic emissions from RAAP.

ATSDR Response: The comment is noted. ATSDR does not have authority to set funding priorities of other agencies.

PC4-19: Please consider the EPA's own TRI data which indicates the health risk we face from RAAP is five orders of magnitude higher than for Americans living around similar chemical manufacturing facilities nationwide, even though emissions from the OBG are not reported on the TRI!

http://oaspub.epa.gov/enviro/rsei.html?facid=24141SDDSRPOBOX [Same link as mentioned by previous commenter PC1 and shown in Figure E-3.]

ATSDR Response: As described in the draft health consultation, the TRI data is a summary of VPDES monthly data. ATSDR used the VPDES monthly surface water release data in evaluating potential exposures from RFAAP. TRI air data were not used because the focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-20: We urge a more in-depth review of ambient air quality downwind of the OBG and well water testing with our tax dollars, as allocated by the Department of Defense for this assessment.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water; ATSDR's evaluation concluded that contaminants released from RFAAP into groundwater and surface water are not affecting either public water supplies or private wells in the area.

ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC4-21: Please note also that the MMA is not located in Radford and the dispersal map shows it is the people living in Pulaski and Montgomery Counties which surround the MMA ought to be the target audience for study and information. It seems that no one in the one mile radius map on page 4 of the report was contacted about the public meetings nor asked for input about their well water quality.

ATSDR Response: The health consultation evaluated exposures for all the areas around RFAAP, not just Radford. ATSDR held a public availability session in February 2013; the session was announced in a media release to local outlets and posted on ATSDR's web site; shared with contacts at partner agencies and local community groups who announced the session on their groups' internet and/or social media sites; and advertised on flyers posted at local shops and post office facilities before the session. Several residents who lived near RFAAP came to the session to discuss their concerns. If they provided their email addresses, they were included on electronic distribution for the release of the draft health consultation and public meeting held May 1, 2014, which was also announced by the same methods as in 2013.

PC4-22: The number of private wells noted on page 7 is a small fraction of those currently in use in this same area. U.S. Census records for 2010 and data readily available from both Montgomery and Pulaski County officials who must approve each new private well, confirm that there are now over 180 private wells in this vicinity, not the small number extracted from data in the 1990's. In fact, a large subdivision, built to accommodate HUD subsidized housing has been built since the 2010 Census at the corner of Route 114 and Prices Fork Road and may be using water supplied by RAAP or a source well. There are a lot of children being born and growing up there who deserve a thorough assessment of their exposure risk.

ATSDR Response: The draft health consultation specifically discussed the fact that the number of private wells in use today is likely far larger than indicated in historical databases. Including the actual number of private wells does not change the conclusions of this evaluation.

PC4-23: I thank you for including and considering my comments as Federal Law dictates.

ATSDR Response: No response necessary.

Comments from Public Commenter #5 (PC5):
PC5-1: I further edited these comments and included the attachments. Please accept these as my final version.

ATSDR Response: As requested by the commenter, the original set of comments are not included herein.

PC5-2: Environmental Patriots invited me to a meeting with Dr. Dyken [the first author of this health consultation] on April 30th at the Inn of Virginia Tech. I met your representatives and discussed with them my concerns about growing up less than a mile from the horseshoe bend area in Montgomery County Virginia. [A family member] [personal medical information] was advised [...] not to drink her private well water. I am deeply concerned about the lack of study in your report regarding the open burning ground and soil contamination.

ATSDR Response: The focus of this health consultation was on whether releases from RFAAP into groundwater or surface water could affect drinking water in the area. The evaluation concluded that private wells are not affected by RFAAP. Because of the local geology, private wells in this area may be affected by surface water or other local sources and we recommend private well owners test their wells for general water quality.

ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report. Results from soil sampling on the site are available, but the community does not have access to the site and cannot come into contact with soil there, so no exposure is possible.

PC5-3: Thus, I have prepared formal public comments:

This is notification of formal submission of the following public comments for the Health Consultation Evaluation of Potential for Chemicals Released to Groundwater or Surface Water to Affect Drinking Water In Nearby Community of the Radford Army Ammunition Plant Radford Virginia EPA Facility ID: VA1210020730

Comment # 1
On Page 38 the report states, "Second, private wells near RFAAP are unlikely to be affected by releases from the facility. Therefore, contaminants from RFAAP in drinking water from private wells near RFAAP are unlikely to harm people's heath."
This conclusion is based on failure to include into the model of risk assessment contamination from airborne particulates from the Open Burning Ground (OBG) passing into the groundwater as a result of rainfall in the nearby community identified in the 2005 Risk Assessment of the Open Burning Ground conducted by CH2MHill INC. While ATSDR officials claim that no data exists on the fallout of the open burning ground or air quality monitoring the Atomic Energy Commissions testing at Operation Buster-Jangle in 1951 and further above ground nuclear operations shows the long history of technologies and science for monitoring air quality. The government has used them for decades in the Nevada Proving Ground Activities. Given that drones can be outfitted with air quality monitors the excuse that no data exists is unacceptable and warrants the further investigation of the connections between soil, air and water contamination at the facility. Testing of the emissions from the OBG must be conducted using over 60 years of air quality monitoring technologies and sciences that were developed during the above ground nuclear testing project at the Nevada Proving Ground combined with the Department of Defense's robust drone program.

ATSDR Response: The commenter is correct that ATSDR did not consider the possible contribution of fallout from air releases from the Open Burning Ground to area groundwater. The health consultation only considered RFAAP releases to groundwater and surface water, as indicated in actual site groundwater and surface water sampling and release data.

ATSDR does not question that technology for measuring air releases from open burning exist. In fact, reports of "bang box" test data was a source of emission factors used in the air modeling performed by CH2MHill and referenced by several commenters [109].[23] *Standard, ground-based air monitoring equipment would be sufficient for collecting ambient air data to describe community exposures.*

ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC5-4: Comment # 2
The failure to include contaminated soil in the report ignores the fundamental connection between land, air and water. When it rains the water passes through the contaminated soil and absorbs contaminates therefore, your report must include a study of soil. By only focusing on the water under the site this report ignore the potential pathways soil and air contamination can enter the water. As water is in the air in the form of water vapor your report is inadequate and does not begin to capture the interdependencies between soil water and air contamination. This lack of scientific rigor fails the community who are asking for robust science with the best available technology used in detection, monitoring, and cleanup of this RCRA site.

ATSDR Response: ATSDR recognizes that soil contamination likely contributed to groundwater and surface water contamination at RFAAP. However, data exists on groundwater and surface water contamination, and in many cases contaminated soil or sources have been addressed or removed. Considering current or past contamination in soil would not add to the evaluation of groundwater and surface water.

As with many scientific evaluations, ATSDR had to focus its efforts on the areas of greatest concern and for which data exist that permit a meaningful evaluation to be done. We recognize that not every possible exposure can be accounted for. That is why this evaluation only includes the exposure pathway which has information and knowledge sufficient for making firm conclusions.

PC5-5: Comment #3
While the report claims "It is physically impossible for substances released to move upstream against the flow of the New River…" , the above conclusion is unacceptable when considering fluid mechanics of a diffusion gradient through a porous medium in the ground water under the

[23] See, for example: Wilcox JL, Entezam B, Molenaar MJ, Shreeve TR. Development of Methods to Account for HCl and CL2 from Open Burning and Characterization of Emissions From the Open Burning of Three Selected Propellants. U.S. Army Dugway Proving Ground. DPG Document No. DPG-TR-96-016. Dugway (UT): September 1996. Accessed online on August 20, 2014 at: www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA348722.

plant. Since the surrounding area and the facility sits upon Karst topography with multiple sink holes identified in the Virginia Department of Mines and Minerals map under the facility and specifically the open burning ground. The report cannot and should not assume the ground water contamination chemicals list identified on pages 63-70 of the report is moving only in the flow of gravity with the river. Rather, the fluid dynamics and mechanics of a diffusion flow process in a porous medium dictates that diffusion can occur against the force of gravity. A simple at home experiment illustrates this effect. Using a Rubber Maid container filled with water on a 30 degree angle with sand and porous limestone with a small 2cm hole on the downhill side of the container, in order to simulate flow, indicates that if food coloring is added at the lowest point of the apparatus the food coloring diffuses upwards through the porous medium against gravity overcoming the 30 degree angle on which the experiment is placed. Furthermore adding food coloring at the bottom of a cup with an eye dropper shows how the material will propagate upwards in the vessel against the flow of gravity.

ATSDR Response: Two forces act on contaminants in the environment: advection and diffusion. Advection refers to transport with the mean fluid flow. Diffusion refers to transport of compounds through random motion. The interaction of these two forces determine the overall direction of contaminant transport. Even in slow-moving groundwater systems (such as porous, unconsolidated sediment), the rate of advection is much greater than that of diffusion, so upgradient diffusion is negligible. Advection in karst geology is typically much greater than in unconsolidated sediment.

Groundwater at RFAAP has been contaminated at several sites, and diffusion and groundwater flow have influenced the extent of contaminant plumes. These plumes of contaminated groundwater are measured and monitored regularly. At RFAAP, the overall groundwater flow (theoretically and as measured in dye trace studies) is towards the New River. If any contamination in the groundwater reaches a spring or other outlet on this large-flow river, it will flow with the river downstream, not upstream, because the advective force of the river water is much, much larger than any diffusive forces acting on contaminants. Mixing in the river due to turbulence and diffusion will then result in the contaminant being diluted by the river's flow.

PC5-6: Comment #4
Your conclusion of page 39 states, "ATSDR does not have site-specific recommendations for well testing since this evaluation showed private wells are unlikely to be affected by RFAAP. However, ATSDR recommends that all private well users monitor the quality of their water well." You are attempting to have your cake and eat it at the same time by basically saying there is no problem, but residents should have their water tested. Given on page 26, Table 7, the Sierra Club well testing of 5 private wells within close range of the arsenal found Perchlorate in 4 out of 5 wells, a chemical signature of activities of the Arsenal, placing the burden on residents to test wells for chemicals not considered in Virginia Tech's extension office water testing program, is unjust and violates the principles of Executive Order 12898 on Environmental Justice. You should consider the diffusion flow process through a porous medium and mandate testing be done on the polluters expense in accordance with the March 1992 HRS Scoring Deficiency Responses as part of the Army Corps of Engineers Preliminary Assessment Report Addendum for the Radford Army Ammunition Plant. By placing the burden of testing on home owners who cannot afford the rigorous testing for obscure chemicals generated by operations at

the arsenal this report mirrors the efforts of the Atomic Energy Commission officials in St. George Utah to hid the effects of nuclear testing on the communities downwind of the Nevada Test Site. The failure to collect data is not an excuse for why data cannot be collected.

ATSDR Response: ATSDR's evaluation showed that private wells are not affected by groundwater or surface water releases from RFAAP, and therefore we do not recommend testing for chemicals specific to the arsenal. ATSDR's recommendation to private well owners is the same as given to any private well owner: general water quality tests such as offered through county testing programs. Please see the detailed response to public comment PC3-5 for a discussion of perchlorate.

PC5-7: Comment #5 The ATSDR Assessment did not include test results from the U.S. Army in 2010, confirming that ground water at 16 of 16 test wells across the Main Manufacturing Area (MMA) have significant perchlorate contamination. The sinkholes at the Open Burning Ground (OBG) and other places in the MMA where the perchlorate persists to this day constitutes an identified point source for cross-contamination through the Karst features beneath all of the MMA. Numerous sinkholes identified by the Virginia Dept. Of Mines & Minerals confirms their potential to serve as conduits for toxins to travel into wells off site. These documented sinkholes in the MMA, including those beneath the Open Burning Ground where perchlorate may have been a component in each of the 233 open burns conducted last year alone, are the "smoking gun" that ought to compel ATSDR to require additional well testing. The widespread perchlorate contamination in soil, surface and groundwater, at RAAP according to the U.S. Army and results from private contractors at RAAP over decades, are facts that cry out for a more thorough risk assessment to safeguard our community.

ATSDR Response: Please see responses to public comments PC1-1 and PC1-7. The draft health consultation included data from original RFAAP reports which were summarized by another group in fact sheets referenced in PC1-1 and restated by this commenter. The draft health consultation recognized that perchlorate in groundwater at some sites on RFAAP was present at concentrations higher than health-based drinking water screening values. However, the evaluation concluded that all groundwater at the site would reach outlets at the New River before encountering any private wells. Groundwater on the opposite side of the New River would also flow towards the river. Sinkholes identified in the Virginia Department of Mines and Minerals open file report were not located at the open burning ground. Sinkholes could exist in the area; but flow through sinkholes would also lead to outlets on the New River.

PC5-8: Comment #6
Clearly, the ongoing contamination of groundwater, soil and surface waters by disposal of waste from Grucci Fireworks at the OBG makes the presence of perchlorate in 4 of 5 wells tested by the Sierra Club a significant finding. It is highly unlikely that the private wells tested were contaminated with perchlorate from any source other than the operations at RAAP. A more sensitive test to differentiate whether it is ammonium perchlorate in these private wells would help to delineate the point source. The data are clear and it seems only prudent and in the interest of public safety to recommend that all municipal and private wells in the areas surrounding RAAP be tested to confirm or disprove cross-contamination from RAAP. The Federal Facility which is the source of the contamination has a moral, if not legal, obligation to pay for the testing

that will ensure citizens are not subject to drinking their toxic waste as disposed of by open burning to the air we breathe and ultimately "rains out" and into the water our children drink. Please see the attached maps from the HHRA of 2005 illustrating the dispersal pattern and reason for our concern. The attached EPA document on perchlorate as an "emerging contaminant" discusses dispersal through soil and substantiates the likelihood that the perchlorate found in 80% of wells tested around RAAP last year is coming from the production and disposal at the facility.

ATSDR Response: The draft health consultation concluded that groundwater or surface water releases from RFAAP would not affect private wells in the area. The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[24] *ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River. The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in these wells is below health-based screening levels and within the range of perchlorate found in a survey of "pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.*

Ammonium perchlorate is highly soluble and dissociates in water to form ammonium and perchlorate ions. While perchlorate is persistent, ammonium could be biodegraded over time. Testing for ammonium perchlorate, unless the concentrations were very high, would not necessarily indicate the original source of the perchlorate [111].[25] *Some isotope-based methods have been proposed to differentiate natural perchlorate from man-made perchlorate, but these have not been fully tested, may not be able to unambiguously determine the original source, and may not be usable for samples with low perchlorate concentrations [110].*[26]

PC5-9: Comment #7
The findings of CH2MHill in their 2005 assessment of the Open Burning Ground performed for Alliant Techsystems included maps of contaminant distribution which are attached. Perchlorate is known to readily leach from the soil where it falls after each burn. As this and other toxins become part of the GW recharge in this Karst aquifer, the potential for widespread diffusion into wells outside of the RAAP boundary is very real. Please note that the CH2MHill study of the OBG indicates "special receptors" for the particulate matter which are upstream of the intake for

[24] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.
[25] Urbansky, ET. Perchlorate Chemistry: Implications for Analysis and Remediation. CRC Pres LLC. 1998. Accessed online on August 20, 2014 at: http://clu-in.org/download/contaminantfocus/perchlorate/urbansky2.pdf.
[26] Trumpolt CW, Crain M, Cullison GD, Flanagan SJP, Siegel L, Lathrop S. Perchlorate: Sources, Uses, and Occurrences in the Environment. Remediation 2005; Winter: 65-89.

the Blacksburg/Christiansburg/VPI Water Authority in addition to numerous points on the river downstream of the OBG.(see River Receptors map). The combination of air dispersal over a wide area and direct deposition into the New River, which serves as a source of drinking water and recreational fishing, is of great concern to our community, especially those using wells and municipal water. (see Receptor Grid map). [note presumed to be map shown in Figure E-4 previously]

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC5-10: The source of perchlorate already found in four private wells is likely to be the Radford Arsenal, which can be confirmed with more extensive and accurate testing. Please note the attached EPA guidance document which confirms how perchlorate moves in soil, the association of perchlorate with the production that has taken place at RAAP since 1941 and most importantly, the importance of this ongoing source of perchlorate, barium, aluminum, chromium and other toxins being emitted from the "skid burns" at the Open Burning Ground. It is incumbent upon your agency to assess our risk to exposure through air and the migration of GW off site of the Arsenal. The tests cited in your report confirming perchlorate in 4 of 5 wells tested simply cannot be ruled out as coming from the documented point sources at RAAP without more testing and analysis.

http://oaspub.epa.gov/enviro/rsei.html?facid=24141SDDSRPOBOX [Same link as mentioned by previous commenter and shown in Figure E-3.]

ATSDR Response: The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[27] *The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in these wells is below health-based screening levels and within the range of perchlorate found in a survey of "pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.*

PC5-11: Comment #8
I implore your agency to recommend testing of all drinking water wells within a three mile radius of the MMA boundary to rule out this route of exposure. The community in this "impact zone," cannot and ought not be asked to bear the financial burden to test for contaminants from

[27] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

the production and waste disposal processes at RAAP. The Dinitrotoluene isomers, chromium other chemicals included in the permit for the OBG at RAAP are specific to their production and unlikely to have any other source - agricultural or otherwise.

ATSDR Response: ATSDR's evaluation showed that private wells are not affected by groundwater or surface water releases from RFAAP, and therefore we do not recommend testing for chemicals specific to the arsenal. ATSDR's recommendation to private well owners is the same as given to any private well owner: general water quality tests such as offered through county testing programs.

PC 5-12: The EPA called for this thorough, extensive testing of all DW wells within a two mile radius of EACH contaminated site in 1992, but that testing was never done. The EPA Deficiency Report for the Hazard Rating Score assigned to RAAP in 1992 makes clear that their risk assessors considered this testing essential to an honest characterization of the risk we face from RAAP. Please afford us the testing and complete risk assessment that was called for by EPA over two decades ago and is now warranted given the detection of perchlorate in wells off site of the facility. Independent testing by an EPA certified lab is the only way for your agency to conclude with certainty that perchlorate and other contaminants unique to RAAP have not migrated through the Karst terrain into the 180 plus private and two municipal wells in the exposure zone shown on the maps from the CH2MHill Risk Assessment of 2005.

ATSDR Response: The referenced "Deficiency Report" (reference [18] in the draft health consultation) does contain a request for private well testing data, and also includes the private well data provided. These results were summarized in the draft health consultation in Table 6, Summary of Historical Sampling Results From Private Wells Near Radford Army Ammunition Plant, and discussed in the text.

PC5-13: Comment # 9
Money should not be an issue for this Federal Facility to fund the widespread testing required at this site. The private contractor operating the facility, BAE Systems, along with the Department of Defense, who owns the facility and paid for this assessment, have the resources at their disposal to finance the testing that will rule out a clear and present threat to the health and safety of our children who drink water and breathe air every day that may be contaminated with the endocrine-disrupting chemical, perchlorate and other RAAP generated toxins.

ATSDR Response: ATSDR's evaluation concluded that contaminants released from RFAAP into groundwater and surface water are not affecting either public water supplies or private wells in the area. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC5-14: Comment # 10
Please note also that the MMA is not located in Radford and the dispersal map shows it is the people living in Pulaski and Montgomery Counties which surround the MMA ought to be the target audience for study and information. It seems that no one in the one mile radius map on

page 4 of the report was contacted about the public meetings nor asked for input about their well water quality.

ATSDR Response: The health consultation evaluated exposures for all the areas around RFAAP, not just Radford. ATSDR held a public availability session in February 2013; the session was announced in a media release to local outlets and posted on ATSDR's web site; shared with contacts at partner agencies and local community groups who announced the session on their groups' internet and/or social media sites; and advertised on flyers posted at local shops and post office facilities before the session. Several residents who lived near RFAAP came to the session to discuss their concerns. If they provided their email addresses, they were included on electronic distribution for the release of the draft health consultation and public meeting held May 1, 2014, which was also announced by the same methods as in 2013.

PC5-15: The number of private wells noted on page 7 is a small fraction of those currently in use in this same area. U.S. Census records for 2010 and data readily available from both Montgomery and Pulaski County officials who must approve each new private well, confirm that there are now over 180 private wells in this vicinity, not the small number extracted from data in the 1990's. In fact, a large subdivision, built to accommodate HUD subsidized housing has been built since the 2010 Census at the corner of Route 114 and Prices Fork Road and may be using water supplied by RAAP or a source well. There are a lot of children being born and growing up there who deserve a thorough assessment of their exposure risk.

ATSDR Response: The draft health consultation specifically discussed the fact that the number of private wells in use today is likely far larger than indicated in historical databases. Including the actual number of private wells does not change the conclusions of this evaluation.

Comments from Public Commenter #6 (PC6):
PC6-1: I am a supporter of the work of the Environmental Patriots of the New River Valley, and have recently been made aware of the findings of the ATSDR regarding the Radford Army Ammunition Plant Study.

I have two specific comments:

1. Given that perchlorate contamination has been found by independent tests in wells near RAAP, and that perchlorate is not a chemical which is likely to have contaminated the water from any source other than RAAP and its operations, I think it is imperative that additional tests be funded for all well owners in the nearby areas. It seems to be a problem that perchlorate is not included in the regular testing of public water. (As a resident of Blacksburg, I regularly receive a report from the Blacksburg-Christiansburg-VPI Water Authority on water testing performed on our water, but it does not include perchlorate.) I suppose this is because it is not a universal risk in drinking water, but only in areas which deal with rocket fuel and fireworks (both of which apply to RAAP). Since perchlorate has the potential to be dangerous in even very small amounts, and especially to children and pregnant women, it seems that both RAAP and government environmental organizations would be interested in doing everything possible to determine if people are being exposed to it.

ATSDR Response: The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[28] ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River. The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in these wells is within the range of perchlorate found in a survey of "pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.

In 2011, EPA published its final regulatory determination on perchlorate in which it decided to regulate perchlorate under the Safe Drinking Water Act [108].[29] This action reversed a 2008 preliminary determination. According to the EPA's website on perchlorate in drinking water (http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm), the regulatory determination initiates a process to develop and establish a national primary drinking water regulation. The website states that perchlorate "can disrupt the thyroid's ability to produce hormones needed for normal growth and development." As of the writing of this report (August 2014), the process for developing and evaluating the proposed rule is ongoing. The proposed rule has not yet been published for public review and comment.

PC6-2: 2. The ATSDR findings did not include any data on contaminants in the air due to open burning at RAAP. I understand that this is because data was not available; there had not been adequate studies done of this. The toxic materials put into the air from burning could possible reach even a much wider area than is affected by possible groundwater contamination. Again, it seems essential that data be collected on this, that studies be funded to determine if there is danger from this burning. I am amazed that this concern dismissed in the report.

ATSDR Response: The focus of this health consultation was on whether groundwater and surface water releases could affect drinking water. ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

PC6-3: Thank you for requesting input on these matters. I am concerned that so many environmental causes of serious health problems can be mitigated if only we have the will and

[28] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

[29] U.S. Environmental Protection Agency. 2011. Drinking Water: Regulatory Determination on Perchlorate. Federal Register 2011 February 11;76:7762-7767.

compassion to do so. I would very much appreciate a considerably more thorough risk assessment regarding this potentially very serious problem.

ATSDR Response: ATSDR is currently looking more closely at existing air pathway information and trying to identify additional information that may help us evaluate the community's exposures to contaminants in air. The air pathway evaluation will consider this comment. ATSDR's findings on the air pathway will be conveyed in a separate report.

Comments from Public Commenter #7 (PC7):
PC7-1: As a resident of the New River Valley, I am very concerned that the Radford Army Ammunition Plant Assessment did not include test results from the U.S. Army in 2010, confirming that ground water at 16 of 16 test wells across the Main Manufacturing Area (MMA) have significant perchlorate contamination.

ATSDR Response: The fact sheet that referenced 16 of 16 test wells with detectable perchlorate was prepared by the Materials of Evolving Regulatory Interest Team (MERIT) and is shown in Figure E-1 earlier in this appendix. MERIT summarized perchlorate groundwater data provided by RFAAP in fact sheets published from 2009 to 2011– the 2011 fact sheet is the one provided in Figure E-1. The MERIT fact sheet summaries are no longer being produced. The fact sheets did not specify the exact location of the samples, so it is impossible to verify the accuracy of all the statements in the fact sheet.

ATSDR considered data from original reports from RFAAP, which included the data used to compile the MERIT summary. For example, the highest perchlorate concentration in groundwater at the Open Burning Ground in 2010 was 143 micrograms per liter, a figure cited in the fact sheet. Not all sites on RFAAP had high levels of perchlorate in groundwater.

PC7-2: The widespread perchlorate contamination in soil, surface, and groundwater, at RAAP clearly indicates that a more thorough risk assessment is necessary. It is highly unlikely that the private wells tested were contaminated with perchlorate from any source other than the operations at RAAP. Please follow up with a thorough analysis of all wells in the vicinity.

ATSDR Response: ATSDR's evaluation concluded that site groundwater would be discharged eventually into the New River before ever reaching private wells in the area. The recent detections of perchlorate in 4 of 5 offsite private wells were all very low (less than one microgram per liter). These detections are lower than ATSDR's health based screening level for perchlorate in drinking water of 7 micrograms per liter.[30] ATSDR does not have exact locations for the private wells tested recently, but we were told the wells were close to the facility in various directions. ATSDR's analysis of groundwater flow patterns indicates that there is no pathway for site groundwater to reach private wells, since all groundwater on both sides of the New River would flow towards and ultimately discharge into the New River. The source of the low levels of perchlorate in private wells is not known, but the concentration of perchlorate in

[30] The health based screening levels used by ATSDR are contaminant concentrations in water, soil, or air that would not be expected to result in any health effects, even if young children were exposed every day for many years. Concentrations higher than screening levels are not necessarily harmful, but further evaluation is done to evaluate potential exposures.

these wells is within the range of perchlorate found in a survey of "pristine" sites across the United States. This indicates that the measured perchlorate detections may not be unique to RFAAP. Because the concentrations detected are below ATSDR's health screening level, there is no public health basis for recommending additional testing. Please see the detailed response to comment PC3-5.

Comments from Public Commenter #8 (PC8):

PC8-1: I am very, very concerned for the people that live in our area because the Radford Army Environmental Assessment did not include testing of water and I understand that the New River water, flowing downstream from the arsenal is not "pure"; that well water that people (especially lower-income people) have to use is not "pure".

ATSDR Response: No water is completely "pure." The EPA sets standards for contaminants in drinking water that public water suppliers have to test for and meet to ensure drinking water supplied is as safe as possible. ATSDR's recommendation to private well owners is the same as given to any private well owner: general water quality tests such as offered through county testing programs. ATSDR's evaluation concluded that contaminants released from RFAAP into groundwater and surface water are not affecting either public water supplies or private wells in the area.

PC8-2: Money should not be an issue for our nation to do more in depth testing. We have plenty of money—one example alone: giving Israel billions http://www.defensenews.com/article/20140330/DEFREG04/303300008/Israel-Banks-10-More-Years-US-Aid Just think what that money could do for testing the water and broader air quality. I am not anti-Israeli, as my father is Jewish and I am proud of my heritage, but I do not believe our tax dollars should be spent for Israel's military, while we are not testing water quality and air quality beyond the immediate area of the arsenal for the sake and health of our own people—so many of whom WORK at the arsenal.

I urge more in-depth review of the air quality beyond the arsenal and ground-water and river-water testing with our tax dollars.

ATSDR Response: Comment noted. ATSDR does not have authority to set funding priorities for other agencies.

PC8-3: Thank you very, very much for requesting input from those who care about our community, especially for the future of our environment and for our fellow citizens.

All the very, very best to all of you for your efforts,

ATSDR Response: Thank you for your comment. No response necessary.