BAE SYSTEMS

RADFORD ARMY AMMUNITION PLANT

RADFORD, VIRGINIA

MULTIPATHWAY RISK ASSESSMENT PROTOCOL FOR THE RADFORD ARMY AMMUNITION PLANT OPEN BURNING GROUNDS

OCTOBER 2015

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Appendix A: Ecological Species Within The Assessment Area

LIST OF ACRONYMS

ADI	average daily intake
ANAD	Anniston Army Depot
AP-42	Compilation of Air Pollutant Emission Factors
BAE	BAE Systems, Ordnance Systems, Inc.
BAP	benzo(a)pyrene
cal/g	calories per gram
CFR	Code of Federal Regulations
CO_2	carbon dioxide
COPC	constituent of potential concern
CSF	cancer slope factor
DEQ	Virginia Department of Environmental Quality
DEM	Digital Elevation Model
D/F	polychlorinated dibenzo(p)dioxins and furans
DOD	United States Department of Defense
DOE	United States Department of Energy
ERA	ecological risk assessment
FOD	foreign object debris
$g/m^2/yr$	grams per square meter per year
GAQM	Guidelines on Air Quality Models
HEAST	Health Effects Summary Tables
HHRAP	Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Biokinetic Uptake Model
IPaC	Information for Planning and Conservation
IRIS	Integrated Risk Information System
km	kilometer
m^3/day	cubic meters per day
$\mu g/m^3$	micrograms per cubic meter
MF	metabolism factor
mph	miles per hour
MPRA	multipathway risk assessment
MPRM	Meteorological Processor for Regulatory Models
MSL	mean sea level
NAD	North American Datum
NCDC	National Climatic Data Center
NCEA	National Center for Environmental Assessment
NRV	New River Valley

NWS	National Weather Service
OBG	open burning ground
OBODM	Open Burning/Open Detonation Dispersion Model
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyls
PICS	products of incomplete combustion
PSA	Public Service Authority (Pulaski County)
RCRA	Resource Conservation and Recovery Act
RFAAP	Radford Army Ammunition Plant
RfD	reference dose
RPF	relative potency factor
SAMSON	Solar and Meteorological Surface Observation Network
SARA	Superfund Amendments and Reauthorization Act
SCRAM	Support Center for Regulatory Air Models
SDWIS	Safe Drinking Water Information System
SLERA	Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities
SSFL	Santa Susana Field Laboratory
TCDD	Tetrachlorinated dibenzo(p)dioxin
TEF	toxicity equivalent factor
TEQ	toxic equivalents
TOE	total organic emissions
USC	United States Code
USCB	United States Census Bureau
USEPA	United States Environmental Protection Agency
USGS	United States Geological Society
UTM	Universal Transverse Mercator coordinate system
Virginia Tech	Virginia Polytechnic Institute
WHO	World Health Organization

1.0 INTRODUCTION

This multipathway risk assessment (MPRA) protocol is being submitted by BAE Systems, Ordnance Systems, Inc., (BAE) to fulfill a requirement of the Resource Conservation and Recovery Act (RCRA) permit application for the open burning grounds (OBG) operated at the Radford Army Ammunition Plant (RFAAP). This protocol documents the methodologies by which BAE proposes to assess the human health and ecological risk resulting from continued operation of the OBG.

This MPRA is being required by the Virginia Department of Environmental Quality (DEQ) under the authority of the RCRA Omnibus provision granted by Title 40 Code of Federal Regulations (CFR) Part 270.32(b)(2). While a prior MPRA was performed for the OBG at the RFAAP, DEQ has requested that a new assessment be performed due to changes in modeling guidance, meteorological data availability, and toxicity data.

1.1 BACKGROUND

Although there are no specific promulgated requirements for MPRAs in RCRA, previous permitting efforts in Virginia and throughout the United States have included this requirement as part of the permitting process for hazardous waste combustion devices. This policy was initiated by the United States Environmental Protection Agency (USEPA) as part of the Hazardous Waste Minimization and Combustion Strategy. Site-specific MPRAs were performed as part of the RCRA permitting process for many hazardous waste combustors to ensure protection of human health and the environment. Specifically, these site-specific MPRAs are intended to address potential concerns about hazardous air pollutants, including dioxins, furans, metals, and non dioxin products of incomplete combustion (PICs). Although hazardous waste open burning grounds were not specifically included in this policy recommendation, DEQ has determined that these waste combustion guidelines are appropriate for application in the OBG permit. As such, an initial MPRA was performed for the OBG as part of the application for the current RCRA permit.

The “omnibus” authority of Section 3005(c)(3) of RCRA, 42 United States Code (U.S.C.) 6925(c)(3), and 40 CFR § 270.32(b)(2) gives the Agency both the authority and the responsibility to establish permit conditions on a case-by-case basis as necessary to protect human health and the environment. Performance of a site-specific MPRA can provide the information necessary to determine what, if any, additional permit conditions are necessary to ensure that operation of the OBG is protective of human health and the environment. Under 40 CFR § 270.10(k), the Agency may require a permit applicant to submit additional information (e.g., a site-specific MPRA) that is needed to establish permit conditions under the omnibus authority. The DEQ has requested that RFAAP perform a MPRA as part of RCRA permit renewal.

1.2 Facility Overview

BAE operates a munitions propellant manufacturing facility at the RFAAP in Radford, Virginia. The primary mission of the RFAAP is to supply solvent and solventless propellant and explosives to the United States Armed Forces. The RFAAP is a government-owned, contractor operated, military industrial installation under the jurisdiction of the United States Army. Manufacturing operations at the RFAAP commenced in 1941 and have been in continuous operation ever since. Currently, the RFAAP is recognized as the largest supplier of ammunition propellant to the United States Department of Defense (DOD) and as a major producer of medium caliber ammunition and commercial and military smokeless powder.

The street address of the RFAAP is:

Radford Army Ammunition Plant
Route 114
Radford, Virginia 24143

All correspondence should be directed to the facility contact at the following address and telephone number:

Mr. Jay Stewart
Environmental Manager
BAE Systems, Ordnance Systems, Inc.
Radford Army Ammunition Plant
4050 Peppers Ferry Road
Radford, Virginia 24141
(540) 639-7785

1.3 Open Burning Grounds Unit Overview

Various types of hazardous waste are generated as part of the RFAAP production operations. These wastes are managed via one of three mechanisms. The hazardous energetic wastes are treated onsite in either the hazardous waste incinerators or the OBG. Non-energetic hazardous wastes are generally sent offsite for disposal.

The OBG receives those wastes that cannot otherwise be treated in the hazardous waste incinerators. This includes wastes containing foreign object debris (FOD) such as screws, rocks, *etc*., that are collected in pits in the operating areas of the facility. In addition, wastes that are too large to process through the incinerators' waste preparation system are managed at the OBG. Combined, these wastes represent less than 40 percent of the total hazardous waste generated and managed onsite. Efforts are continuously underway to reduce this percentage through waste minimization efforts and the implementation of innovative production and waste treatment technologies.

1.4 Study Area Description

The RFAAP is situated in hilly terrain in Pulaski and Montgomery Counties in southwest Virginia and is divided into two sections: the main plant, and the horseshoe area. The New River separates the two counties and these two portions of the facility. The OBG is located in the lower southeast portion of the horseshoe area, as shown on Figure 1-1. Surrounding land use is primarily a combination of deciduous forest and pasture land, intermingled with small residential areas. The main developed areas are Blacksburg to the northwest, Christiansburg to the east, and Radford to the southwest. The location of these towns relative to the RFAAP is demonstrated on Figure 1-2.

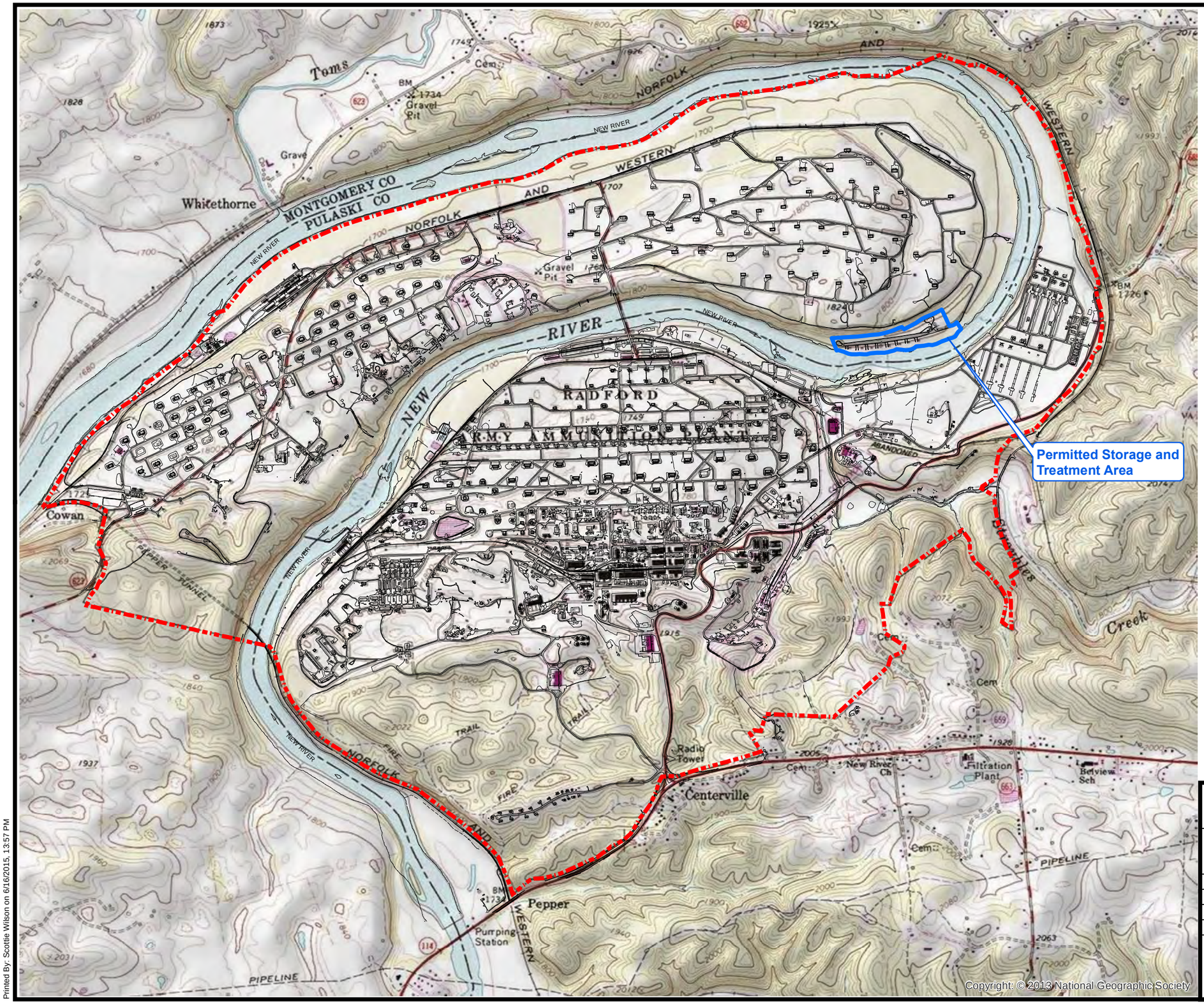
Preliminary consideration of the air modeling results provided with the initial MPRA suggests that the most significant locations for maximum ground level air concentrations or deposition rates for the OBG will occur to the southeast of the facility within the first three kilometers. Offsite exposures in this direction are mitigated by Price Mountain, which bounds the southeastern portion of the facility. For the MPRA, however, USEPA guidance indicates that a 10-kilometer (km) radius is usually more appropriate for air dispersion and deposition modeling. Figure 1-2 shows this larger area on a map along with the 3-km and 10-km markers.

With hilly terrain and numerous drainage areas, the area surrounding the RFAAP provides multiple streams and creeks for fishing. In addition, the New River itself, serves as a major resource for fishing, supporting outstanding populations of just about every major freshwater game fish in the state, including: smallmouth bass, spotted bass, largemouth bass, rock bass, striped bass, white bass, hybrid striped bass, muskellunge, walleye, black crappie, channel catfish, flathead catfish, yellow perch, redbreast sunfish, and bluegill. Due to the abundance of opportunity for fishing on the New River and in these numerous creeks and streams, smaller ponds within the assessment area are generally not used for catching fish on a reliable consumption basis. Therefore, these small ponds and lakes will not be considered in the MPRA. In addition, several of the waterbodies within the area are used as a drinking water supply for nearby communities. Therefore, this assessment will consider impacts of emissions on drinking water sources.

The most ecologically significant areas appear to be those along the New River and in the Jefferson National Forest, which is located north of the facility. However, ecological species of conservation concern have been located within the entire assessment area. A conceptual site model will be presented in the MPRA that summarizes the study area description and site characterization activities.

1.5 Purpose and Scope

BAE is submitting this MPRA protocol in conjunction with the renewal application for the OBG RCRA permit. The MPRA will be conducted in accordance with the methods described in USEPA's guidance document entitled, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion*



LEGEND

- Facility Property Boundary
- Permitted Storage and Treatment Area

WIND SPEED

(Knots)

- >=22
- 17-21
- 11-17
- 7-11
- 4-7
- 1-4

Calms: 36.97%

NOTE: SOURCE OF WINDSPEED DATA IS THE VIRGINIA TECH KENTLAND FARM WEATHER STATION. DISPLAY IS THE DIRECTION THE WIND IS BLOWING TO.

N

0 1,000 2,000
Feet

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

RFAAP SITE LAYOUT

DRAWN BY: S S WILSON	SCALE:	PROJ. NO.	ENV MAPS 2012
CHECKED BY: M GEHRING	AS NOTED	FILE NO.	RF-TOPOMAP.mxd
APPROVED BY:	DATE PRINTED:	**FIGURE 1-1**	
DATE: June, 2015	*6/16/2015*		

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10 Kilometer Radius

3 Kilometer Radius

Radford Army Ammunition Plant

Giles County

Pulaski County

Radford County

Montgomery County

REGIONAL MAP

RFAAP

LEGEND

Facility Property Boundary

Distances to nearest cities	
City Name	Distance
Radford	4 miles S
Blacksburg	7 miles NE
Christianburg	9 miles SE
Roanoke	30 miles E

N

0 1 2 4

Miles

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

LOCATION MAP

DRAWN BY: S S WILSON	SCALE:	PROJ. NO.	ENV MAPS 2012
CHECKED BY: M GEHRING	AS NOTED	FILE NO.	RF-LOCATIONMAP.mxd
APPROVED BY:	DATE PRINTED:	**FIGURE 1-2**	
DATE: June, 2015	*6/16/2015*		

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Facilities (HHRAP). In addition, any applicable information presented in USEPA's August 2, 1999 *Errata to the HHRAP* will be incorporated into the MPRA. An ecological screening assessment will be conducted in accordance with the guidelines provided in USEPA's 1999 *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (SLERA). The MPRA will be site-specific with respect to the source and dispersion of constituents of potential concern and the locations of potential receptors. Default variable values will be used to represent the potential intake of the hypothetical receptors. Both human and ecological receptors will be addressed.

This MPRA protocol presents the following information:

- Identification of constituents of potential concern based on waste stream characterizations;
- Definition of potentially completed site-specific exposure pathways and hypothetical receptors;
- Description of procedures to be used in the estimation of risk associated with potential direct and indirect exposures to incinerator emissions; and
- Development, as appropriate, of site-specific risk-based emission limits.

The goal of the MPRA described by this protocol document is to demonstrate that emissions from the OBG meet the site-specific risk-based emission standards established by the DEQ.

2.0 COMPOUNDS OF POTENTIAL CONCERN

Compounds of potential concern (COPCs) are those compounds that will be evaluated throughout the MPRA. COPCs in the emissions from hazardous waste combustion units vary widely, depending on (1) the type of combustion unit, (2) the type of hazardous waste feed being burned, and (3) the type of air pollution control systems used. For those systems without any air pollution control such as the OBG, the mix of hazardous waste that is burned at the facility is the largest single contributor to COPC generation. COPCs can represent compounds initially present in the hazardous waste feed stream and not completely destroyed in the combustion process, as well as compounds that are formed during the combustion process.

2.1 IDENTIFICATION OF SITE-SPECIFIC COPCS

COPCs are identified based on their potential to pose increased risk or hazard via one or more of the exposure pathways. This identification process is focused on compounds that:

- are likely to be emitted, based on the presence of the compound or its precursors in the waste feed and emissions;
- are potentially toxic to humans; and/or
- have a propensity for bioaccumulating or bioconcentrating in food chains.

The previous MPRA performed for the OBG relied on a combination of data to generate the COPC list for the assessment, including "bang-box" data generated by the Department of Energy (DOE) at a test facility and emissions data collected from the onsite incinerators. None of these data sources were specific to OBG operations at the RFAAP. The "bang-box" data did not specifically target the propellants or waste mix burned at the RFAAP, and the incinerator utilizes a staged combustion process and air pollution control system, neither of which the OBG utilizes. Therefore, for this MPRA, there is a desire to utilize more site-specific and OBG-specific data for generating the COPC list.

2.1.1 SITE-SPECIFIC EMISSIONS SAMPLING

To help generate site-specific emissions data for the MPRA, RFAAP is currently working with the USEPA to develop a sampling and analytical program for OBG emissions. This testing will utilize USEPA's flyer sampling device to collect emission samples from the OBG emission plume. At this time, RFAAP and USEPA are hoping to collect data on the following pollutant groups:

- Particulate matter;
- Metals, including RCRA metals and hexavalent chromium;
- Chloride, perchlorate, and hydrogen chloride;
- Dioxins and furans;
- Semivolatile and volatile organic compounds, including targeted energetics; and

- Polynuclear aromatic hydrocarbons.

A complete sampling and analytical protocol for the flyer study will be developed and submitted to DEQ under separate cover once all components of the program have been finalized.

Once this data is collected, RFAAP will evaluate the data to determine its usability for the MPRA. Assuming that the data USEPA collects meets acceptable quality criteria and provides acceptable limits of quantitation, this data will be used to develop site-specific emission factors for each of the identified COPCs. The following guidelines will be used to determine the COPC list:

- Compounds detected in one or more test run samples and not meeting any of the exclusion criteria below will be included in the MPRA;
- Compounds reported as non-detect in all of the test run samples will excluded from the COPC list;
- Compounds present in test run samples that are also present in the method blank at greater than 50 percent of the test level will be excluded from the COPC list; and
- Compounds without any chemical specific fate, transport, and/or toxicity data will be excluded from the COPC list, but will be discussed qualitatively in the MPRA report.

2.1.2 Supplemental Emission Factors

In addition to the site-specific emission data collected with USEPA's flyer, RFAAP will consult USEPA's *Compilation of Air Pollutant Emission Factors* (AP-42) for open burning found Chapter 15 of the 5th edition. These emission factors were developed for different types of ordnance ranging from small, medium, and large caliber ammunition to grenades, rockets, mines and simulators. While these actual ordnance items are not open burned at the RFAAP, many of the propellants used in them are. Therefore, applying the AP-42 emission factors to the RFAAP emission profile is appropriate. This data is more recent than the DOE bang-box data and has been subject to extensive quality evaluations, peer reviews, and public review and comment. Therefore, absent site-specific emissions data, these factors are considered the most appropriate for consideration.

This study evaluated emissions from many of the same pollutant categories that are generally included in site-specific MPRAs (*e.g.* metals, volatile and semivolatile organic compounds, dioxin and furan compounds, *etc*.). The worst-case emission factors for these pollutants from each of the ordnance items with propellant formulated similar to that open burned at the RFAAP will be used in the MPRA unless:

- The site-specific flyer data provides better resolution of emissions for that pollutant or confirms its absence in RFAAP OBG emissions; and/or
- RFAAP propellant formulation data supports exclusion of the pollutant from the evaluation (*e.g.,* if no RFAAP propellants contain fluorine, than no fluorinated organic compound will be included in the MPRA).

2.2 Discussion of Selected COPCs

Although the specific COPCs that will be assessed in the MPRA cannot be determined until the site-specific emissions testing is complete, the types of COPCs that will be evaluated in the MPRA can be discussed on a more general level based on data collected from the prior MPRA. In general, the COPCs from the following compound classes will likely be included in the MPRA:

- Dioxins and furans;
- Polynuclear aromatic hydrocarbons;
- Nitroaromatics;
- Phthalates;
- Other semivolatile and volatile organics;
- Metals; and
- Chlorine and perchlorates.

A more focused discussion on each of these classes of compounds is provided in the sections that follow. Information is also provided on specific compound classes that will be excluded from the assessment.

2.2.1 Dioxins and Furans

Carcinogenic and noncarcinogenic effects associated with exposure to dioxins and furans (D/F) will be evaluated in the MPRA. The D/F that will be included in the MPRA are the 17 congeners with chlorine in the 2, 3, 7 and 8 positions, as recommended in the HHRAP. This MPRA will not attempt to quantify the formation and dispersion of other D/F analogs, such as the fluorinated, brominated and sulfonated analogs. The potential for the formation of fluorine, bromine, and sulfur D/F analogs will be addressed in the uncertainty analysis of the MPRA report.

Carcinogenic and noncarcinogenic risks for D/F will be evaluated based on the relative toxicity of 2,3,7,8-tetrachlorinated dibenzo(p)dioxin (2,3,7,8-TCDD). The exposure media concentrations of the individual D/F congeners will be converted to a 2,3,7,8-TCDD Toxicity Equivalents (TEQ) by multiplying the observed concentrations by congener specific Toxicity Equivalent Factors (TEFs) provided in Section 5.3. The available cancer slope factor and oral reference dose will then be used to determine the human health impacts.

2.2.2 Polynuclear Aromatic Hydrocarbons

Carcinogenic effects associated with exposure to polynuclear aromatic hydrocarbons (PAHs) will be evaluated in the MPRA. Noncarcinogenic effects will not be considered, as the "uncertainties associated with attempting to quantify the potential noncarcinogenic effects…is considered greater than the uncertainty associated with not evaluating the potential effects" (HHRAP). Only those PAHs listed in the HHRAP and identified via the procedures in Section 2.1 will be considered in the MPRA.

To determine the carcinogenic effects from these compounds, the BaP-RPF equivalency method will be -used. Concentrations of the individual PAHs will be converted to a benzo(a)pyrene (BaP) equivalency, and will be summed to determine the total equivalent concentration of BaP. The total BaP equivalent concentration, the BaP cancer slope factor, and the BaP fate-and-transport properties presented in the HHRAP will then be used to estimate total risk from all carcinogenic PAHs that are evaluated.

2.2.3 Polychlorinated Biphenyls

This MPRA will not include an evaluation of polychlorinated biphenyls (PCBs) in emissions from the OBG. As stated in the HHRAP, PCBs should only be "included as COPCs for combustion units that burn PCB-contaminated wastes or waste oils, highly variable waste streams, such as municipal and commercial waste for which PCB contamination is reasonable, and highly chlorinated waste streams." The HHRAP defines "highly chlorinated waste streams" as waste streams that contain more than 60 percent chlorine. None of the waste streams treated at the OBG meet the definition of being "highly chlorinated." In addition, the waste streams treated at the OBG lack the variability or PCB content to justify PCB inclusion in the MPRA.

2.2.4 Nitroaromatics

This MPRA will include the assessment of nitroaromatic compounds. As described in the HHRAP, these compounds generally are not formed as PICs unless they are present in the waste stream. Nitroaromatic compounds and related compounds, such as dinitrotoluene, are present in the waste stream. Therefore, it is appropriate to include this class of compounds in the assessment. The specific nitroaromatics that will be included will be identified via the procedures in Section 2.1.

2.2.5 Phthalates

Although the HHRAP states that there is no apparent mechanism for phthalate PICs to be formed by the combustion of other chemical compounds, the guidance also notes that facilities that burn wastes containing phthalate compounds should consider them in the MPRA, if for no other reason than to confirm their absence. The waste burned at the OBG may contain low concentrations of some phthalate compounds, and for this reason, phthalates will be evaluated in the MPRA. The specific phthalates that will be included will be identified via the procedures in Section 2.1.

For the indirect exposure pathways, a metabolism factor (MF) of 1.0 will be used for all evaluated phthalates. The MF will only be applied to the intake of food sources in evaluation of indirect exposure. Direct exposures to air, soil, or water, or to ingestion of produce, chicken, or fish will not be considered using a MF.

2.2.6 Other Semivolatile and Volatile Organics

Other semivolatile and volatile organic compounds identified via the procedures in Section 2.1 will be included in the MPRA. All of the semivolatile and volatile organics identified via Section 2.1 will be considered in each exposure scenario identified in Section 4, as long as there is sufficient fate and transport properties available for the organic compound of concern.

2.2.7 TOTAL ORGANIC EMISSIONS

No emissions sampling will be performed for total organic emissions (TOE). In general, TOE data is not used for any quantitative assessment of risk in MPRAs. It is typically only used to for discussions on uncertainty in the MPRA. RFAAP will include an uncertainty discussion in the MPRA report and will use data from other studies to help determine the uncertainty associated with unquantified emissions.

2.2.8 METALS

The final list of metals included in the MPRA will not be established until the site-specific emission study is complete. However, historical data on the process formulations and previous MPRA provide some direction as to the metals that will likely be included. Some of these metals require specific discussion regarding their handling in the MPRA.

2.2.8.1 Chromium

USEPA has indicated that chromium emitted from a combustion unit is not likely to be in the hexavalent form; however, there is not sufficient evidence to reliably estimate the partitioning of chromium emissions into its two typical valence states (trivalent and hexavalent). Therefore, the site-specific emissions evaluation included in Section 2.1 will attempt to quantify the speciation between the two forms. In the event that this data is not of sufficient precision to be used in the MPRA, it will be assumed that 100 percent of the chromium emissions are in the hexavalent form. Furthermore, in the event risks or hazards associated with chromium exceed target levels based on the initial conservative assumption that exposure is entirely to hexavalent chromium, risks and hazards may be recalculated assuming potential receptors are exposed through indirect exposure pathways to trivalent chromium. The risk and hazards associated with the exposure to hexavalent chromium will be discussed in the uncertainty section of the MPRA report.

2.2.8.2 Lead

As discussed in the HHRAP, threshold levels for exposure to lead have not been established. Consequently, in performing a lead evaluation as part of a MPRA, values for reference doses (RfDs) and cancer slope factors (CSFs) are not available. USEPA has, however, expressed the desire for lead to be evaluated in MPRAs given the concern over the potentially harmful effects that lead can have on humans, particularly on children, who are more susceptible to exposure because of higher soil ingestion rates, greater gut absorption rates, certain nutritional values, and lower body weight. To provide for a uniform approach in this assessment, USEPA has developed and released the Integrated Exposure Uptake Biokinetic (IEUBK) model for Lead in Children. This model can be used to evaluate the potential risks to children based on predicted blood lead levels and distributions determined from model calculations and several assumptions about the exposure pattern and physiological handling of lead by the body.

Therefore, per recommendations presented in the HHRAP, this MPRA will utilize the IEUBK model to evaluate the effects of lead emissions from the combustion unit.

2.2.8.3 Mercury

As stated in the HHRAP, combustion emissions are thought to include both vapor and particle-bound forms of mercury, speciated as both divalent and elemental mercury. However, current stack gas analytical methods do not provide for an accurate and approved method for determining mercury speciation in the combustion gases. Therefore, due to these limitations, all analyses conducted for this MPRA will be for total mercury. To determine the approximate amount of mercury that is distributed in the vapor and particle bound phases, this MPRA will utilize the assumptions concerning mercury speciation that are presented in the HHRAP and that are outlined below:

- Total mercury in the OBG emissions is distributed as 80 percent the vapor phase (60 percent in the divalent vapor form and 20 percent in the elemental vapor form) and 20 percent in the particle-bound phase.
- Approximately 99 percent of the elemental vapor phase of mercury does not deposit to the surface, but rather is vertically diffused to the free atmosphere. Roughly 68 percent of the vapor phase divalent mercury is deposited and 32 percent of the vapor phase divalent mercury is vertically diffused to the free atmosphere.
- The particle-bound mercury is assumed to be in the divalent form. Approximately 36 percent of the particle-bound mercury is deposited and the remaining 64 percent is vertically diffused to the free atmosphere.
- Of the total mercury in the soil, 98 percent will be assumed to be divalent mercury and the remaining two percent will be assumed to be methyl mercury.
- Furthermore, 85 percent of total mercury in surface water will be assumed to be divalent mercury and the remaining 15 percent will be assumed to be methyl mercury.

These assumptions and their effect on the MPRA results will be discussed in the uncertainty section of the MPRA report.

2.2.9 CHLORINE AND PERCHLORATES

Due to the site-specific concerns associated with perchlorate emissions from the OBG, chlorine and perchlorate emissions will be measured as part of the emission study and assessed in the MPRA. The impact from these pollutants will be considered in all of the assessed exposure pathways.

3.0 DISPERSION AND DEPOSITION MODELING

An air dispersion modeling analysis will be performed to support the MPRA. The modeling will be used to estimate the ambient air concentrations and deposition rates at selected receptor sites surrounding the OBG and will provide the data to perform the MPRA. This section describes the air dispersion model selection, the model options to be selected, and the input data required by the model. The modeling will incorporate the procedures outlined in the HHRAP. The modeling approach will be consistent with the USEPA Guidelines on Air Quality Models (GAQM) codified as 40 CFR Part 51, Appendix W.

3.1 MODEL SELECTION

The most recent version of the Open Burning/Open Detonation Model (OBODM) version 02092010 available from USEPA's Support Center for Regulatory Air Models (SCRAM) will be used to complete the air modeling in this MPRA. OBODM was developed for the open burning and open detonation of obsolete munitions and propellants. OBODM is a Gaussian puff model that uses cloud/plume rise, dispersion, and deposition algorithms taken from existing models for instantaneous and quasi-continuous sources to predict the downwind transport and dispersion of pollutants released by the combustion of propellants. Completion of modeling using OBODM requires numerous inputs on surrounding land use, source characteristics, meteorological data, and model control options.

3.2 MODEL INPUTS

Various types of information on the emission location, source, and materials are required to execute the OBODM model. These include information on the land use characteristics at the site, the emission scenarios (*e.g.,* mass and dimensions of material, burn time), and treated material characteristics (*e.g.,* pollutant type and emission rate, heat of combustion). The sections that follow provide information on each of these input parameters.

3.2.1 LAND USE CLASSIFICATION AND DISPERSION COEFFICIENTS

The USEPA GAQM presents a discussion of rural and urban land use determinations. For this analysis, the land use will be determined using a technique proposed by Auer in Correlation of Land Use and Cover with Meteorological Anomalies. This method is recommended in the USEPA document Regional Workshop on Air Quality Modeling: A Summary Report. The method is used to classify the area within a three-kilometer radius of the source as urban or rural. The Auer method uses twelve different classifications for land use. In this method, areas of industrial, commercial, and compact residential land use are designated urban. Low density residential, water surfaces, agricultural, undeveloped, and natural areas are designated rural. According to USEPA procedure, if more than 50 percent of an area circumscribed by a 3-km radius about the source is classified urban, then urban coefficients should be used; otherwise, the area is considered rural.

A land use map for the assessment area was generated from the National Land Cover Database developed by the Multi-Resolution Land Characteristics Consortium. As shown in Figure 3-1, the land use within the immediate region is primarily forested land, with intermittent sections of pastures and fields used for crop production. Table 3-1 provides the relative percentage that each land use classification represents within this 3-kilometer radius. As shown in the table, the vast majority of the surrounding land meets the rural classifications established under the USEPA procedure. Therefore, rural dispersion coefficients will be used.

TABLE 3-1
LAND USE PROPORTIONS WITHIN THE ASSESSMENT AREA

LAND USE TYPE	CATEGORY	PERCENTAGE
Open water	Rural	4.6%
Developed, open space	Rural	11.4%
Developed, low intensity	Rural	17.4%
Developed, medium intensity	Urban	5.1%
Developed, high intensity	Urban	1.8%
Deciduous forest	Rural	45.6%
Evergreen forest	Rural	2.8%
Mixed forest	Rural	0.3%
Grassland/herbaceous	Rural	0.3%
Pasture hay	Rural	10.1%
Cultivated crops	Rural	0.5%
Total Rural		**93.1%**
Total Urban		**6.9%**

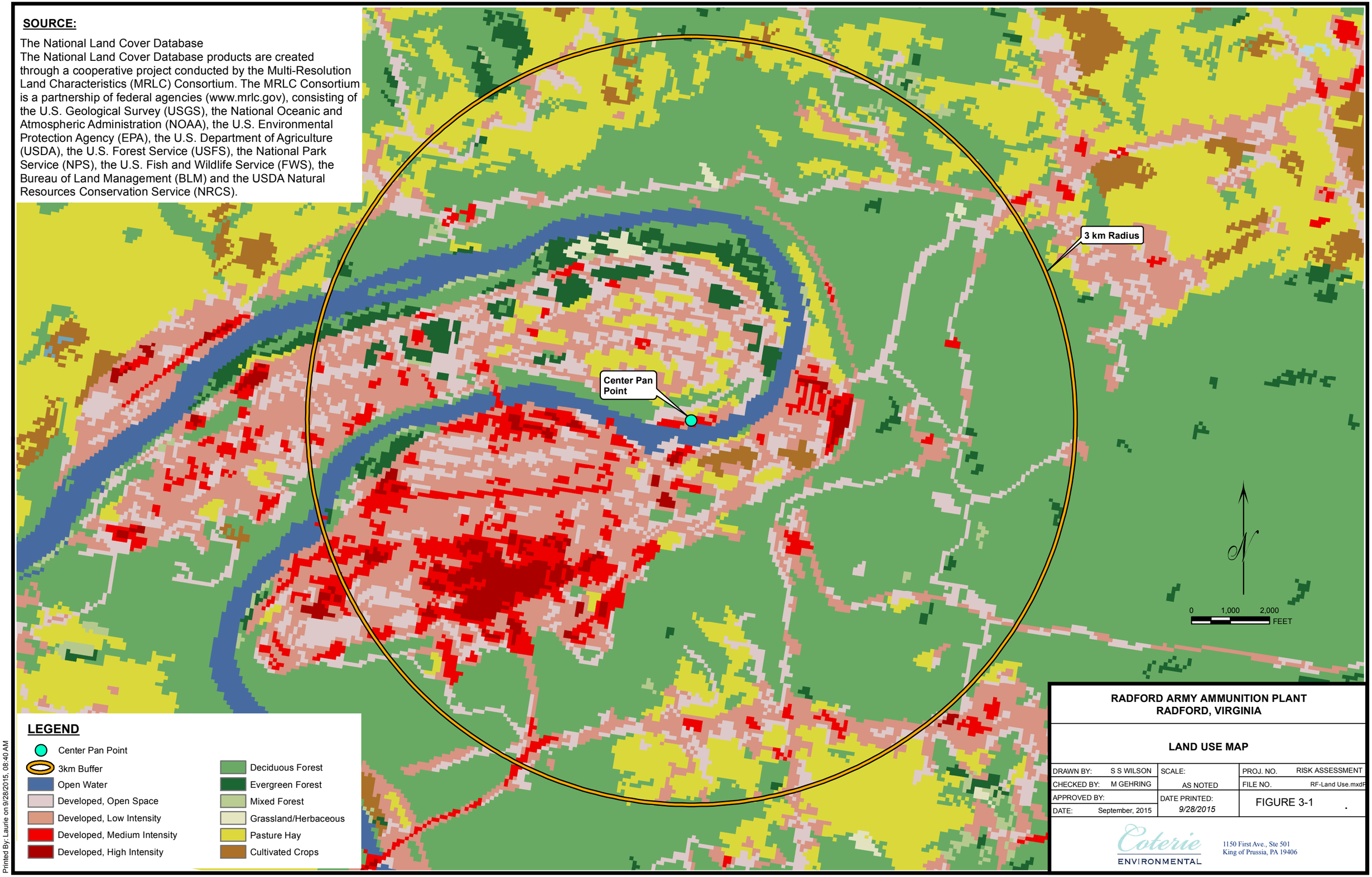
3.2.2 EMISSION SCENARIOS

Two main emission scenarios exist for the OBG operations at the RFAAP: skid burns and propellant burns. Skid burns are burns involving a combination of energetic material, dunnage (*e.g.,* cardboard and wooden pallets), and fuel oil. The dunnage and fuel oil are intended to help aid in and sustain the materials being burned. Skid burns are typically used for pit wastes, which may contain significant amounts of soil and other foreign object debris and small amounts of energetic material. Conversely, propellant burns consist entirely of energetic material that is laid directly on the pan.

In each burning scenario, the burn pans are loaded with waste and sequentially ignited, beginning with the most downwind pan and proceeding in sequence to the closest pan. Each 18-foot by 6-foot pan has a maximum capacity of 1,000 pounds. Typically the pans are loaded to 3 inches in height; however, for certain bulking wastes (*e.g.*, MK-90 ribbons and shavings), the pans may be loaded to a maximum height of 6 inches. Recognizing that generally only half of the pans are ignited during any burn, the total maximum capacity for a burn on a given day is 8,000 pounds. If operation is assumed to occur 365 days

SOURCE:

The National Land Cover Database
The National Land Cover Database products are created through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies (www.mrlc.gov), consisting of the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), the U.S. Forest Service (USFS), the National Park Service (NPS), the U.S. Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM) and the USDA Natural Resources Conservation Service (NRCS).



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LAND USE MAP

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CHECKED BY: M GEHRING	AS NOTED	FILE NO.	RF-Land Use.mxdP
APPROVED BY:	DATE PRINTED:	FIGURE 3-1	
DATE: September, 2015	9/28/2015		

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per year, this results in a total amount of 2,920,000 pounds treated on an annual basis. In reality, significantly less amounts of material are burned. In the last three years, the average amount of material processed at the OBG was approximately 374,000 pounds per year.

Open burning operations happen once per day, with ignition occurring between 0800 and 1700 hours. Ignition may begin as soon as 1/2 hour after dawn or as late as 1/2 hour before dusk. The propellant burns typically finish in less than 30 seconds; the wooden skids used in the skid burns can last up to 7 hours. It is assumed that at least one pan per day will require a skid. For modeling purposes, the propellant burn will be assumed to last for five minutes. For the skid burn, the burn duration is assumed to be one hour, as this is the maximum burn duration that can be run within the OBODM model. This is expected to provide a larger source term than the actual scenario, which distributes the emissions over a longer period. These restrictions will incorporated into the OBODM model runs to limit modeling events such that they only occur between 0800 and 1700 hours.

In addition to limiting burning operations to daylight hours, RFAAP also requires favorable weather conditions to burn. Burning may not be conducted when there are thunderstorms in the vicinity. If there is no precipitation occurring when the pans are ready for ignition, burning will commence. If the wind speed is less than 3 miles per hour (mph) or greater than 15 mph, the RFAAP safety officer must give permission to ignite the pans if they have already been loaded. However, once a pan has been loaded, the waste cannot be safely removed. Absent these restrictions, burning can happen at any time within the daylight window. To account for this variable, meteorological constraints will be added to the OBODM modeling runs. Disposal events will be restricted to periods with wind speeds between 3 mph and 15 mph and to those periods when precipitation is not occurring.

Table 3-2 provides an overall summary of these two emission scenarios and how they will be incorporated to the OBODM source profile.

TABLE 3-2
SUMMARY OF EMISSION SCENARIOS

SOURCE PARAMETER	SKID BURN	PROPELLANT BURN
Maximum amount of waste (total)	2,000 pounds	8,000 pounds
Maximum amount of waste (per pan)	1,000 pounds	1,000 pounds
Number of pans	8	8
Volume of each pan	18 ft x 6 ft x 0.5 ft	18 ft x 6 ft x 0.5 ft
Effective height of release	1.25 ft (top of pan)	1.25 ft (top of pan)
Duration of burn	1 hour	5 minutes
Hours for burn	0800 - 1700 hours	0800 - 1700 hours
Conditions for burn Wind speed Precipitation	 3 mph - 15 mph No precipitation occurring	 3 mph - 15 mph No precipitation occurring

3.2.3 MATERIAL CHARACTERISTICS

OBODM allows the user to select a treatment material from a list of candidate material types. For each candidate material, OBODM has pre-populated information on physical characteristics, constituent products, and byproducts. The treatment material selected can have a significant impact on the resulting characteristics. For example, those materials with a higher heat content will burn faster and hotter and will tend to disperse further, resulting in a different puff of material than a cooler, longer burn, which will tend to deposit closer to the source location. In addition, the constituents in that material, whether vapor phase constituents or particle phase constituents will impact the outcome of the model. Two distinct phases of pollutants are generally emitted from an open burning operation: particle phase pollutants and vapor phase pollutants. The division of compounds between phases can typically be determined based on the pollutant's fugacity coefficient. In most cases, inorganic COPCs, which have low volatility, will occur in the particle phase, and highly volatile organic COPCs will occur in the vapor phase. The MPRA report will identify the fugacity coefficient for each COPC and specify the phase in which it was assumed to occur.

Rather than model every COPC emitted from the OBG, surrogate COPCs will be modeled on a unit basis, using an emission factor of 1 pound of pollutant emitted to 1 pound of energetic material burned. The modeled results will then be converted to a pollutant-specific basis using the site-specific emission factors developed from the USEPA flyer testing (or other data if the flyer data is deemed unacceptable). One surrogate compound will be chosen for the vapor phase pollutants and another surrogate compound will be chosen for the particle phase pollutants. For the vapor phase COPCs, carbon dioxide (CO_2) will serve as the surrogate compound, as it is a common vapor-phase occurrence in OB emissions. Aluminum, which is found in many of the materials treated via open burning at the RFAAP, will be utilized as the surrogate compound for the particle phase modeling. The characteristics associated with each surrogate COPC are provided in Table 3-3.

TABLE 3-3
CHARACTERISTICS OF SURROGATE POLLUTANTS

PARAMETER	VAPOR PHASE SURROGATE	PARTICLE PHASE SURROGATE
Surrogate pollutant	Carbon dioxide (CO_2)	Aluminum (Al)
Pollutant molecular weight	44 g/gmol	27 g/gmol
Pollutant density	0.002 g/cm	2.7 g/cm

As discussed previously, the heat content of the material also has a significant impact on the dispersion of the plume from the source. Rather than model every type of energetic material disposed at the OBG, the modeling activity will be bound by the energetic materials with the highest and lowest heat contents. One model run will be performed for each type of propellant burn with the energetic material having the highest heat content and one run will be performed using the material with the lowest heat content. Because the variation of heat content in skid burns is much smaller and generally reflective of

the dunnage and fuel materials rather than the energetic contaminated material, one model run will be performed using a heat content appropriate for dunnage and diesel (1,000 cal/g).

3.2.4 Geographical Inputs

OBODM requires certain information on the source location to complete the modeling. This includes the x and y coordinates of each pan, as well as the base elevation of the pan. Table 3-4 provides a summary of this information for each of the 16 pans used at the RFAAP. Pad locations and base elevations were established from onsite measurements with a geographic positioning device.

Table 3-4
Geographic Coordinates for Modeled Source

Pad No.	Pan No.	UTM Easting [1]	UTM Northing [1]	Elevation [2]
1	East	542,417	4,116,153	1,694
	West	542,405	4,116,150	1,694
2	East	542,360	4,116,143	1,694
	West	542,347	4,116,141	1,694
3	East	542,303	4,116,132	1,695
	West	542,291	4,116,129	1,695
4	East	542,247	4,116,121	1,695
	West	542,234	4,116,118	1,695
5	East	542,188	4,116,113	1,695
	West	542,177	4,116,112	1,695
6	East	542,131	4,116,105	1,697
	West	542,119	4,116,103	1,695
7	East	542,075	4,116,102	1,696
	West	542,061	4,116,102	1,696
8	East	542,015	4,116,107	1,696
	West	542,003	4,116,109	1,696

[1] Pan locations provided in Universal Transverse Mercator (UTM) coordinate system, NAD27 datum.
[2] Elevations provided feet above mean sea level.

3.3 Receptor Grid

The receptor pathway identifies sets or arrays of receptor grid nodes identified by Universal Transverse Mercator (UTM) coordinates for which the air model generates estimates of ambient air concentrations and deposition rates. The HHRAP recommends that, at a minimum, an array of receptor grid nodes covering the area within 10 km centered at the source be used. This receptor grid should consist of a Cartesian grid with nodes spaced not greater than 100 meters apart extending from the source out to 3 km. For distances from 3 km out to 10 km, the spacing can be increased to not greater than 500 meters. Additionally, fenceline receptors, which are receptors located along the property boundary, should be

spaced at intervals of no greater than 100-meter spacing in order to estimate maximum annual concentrations and deposition rates at the property boundary.

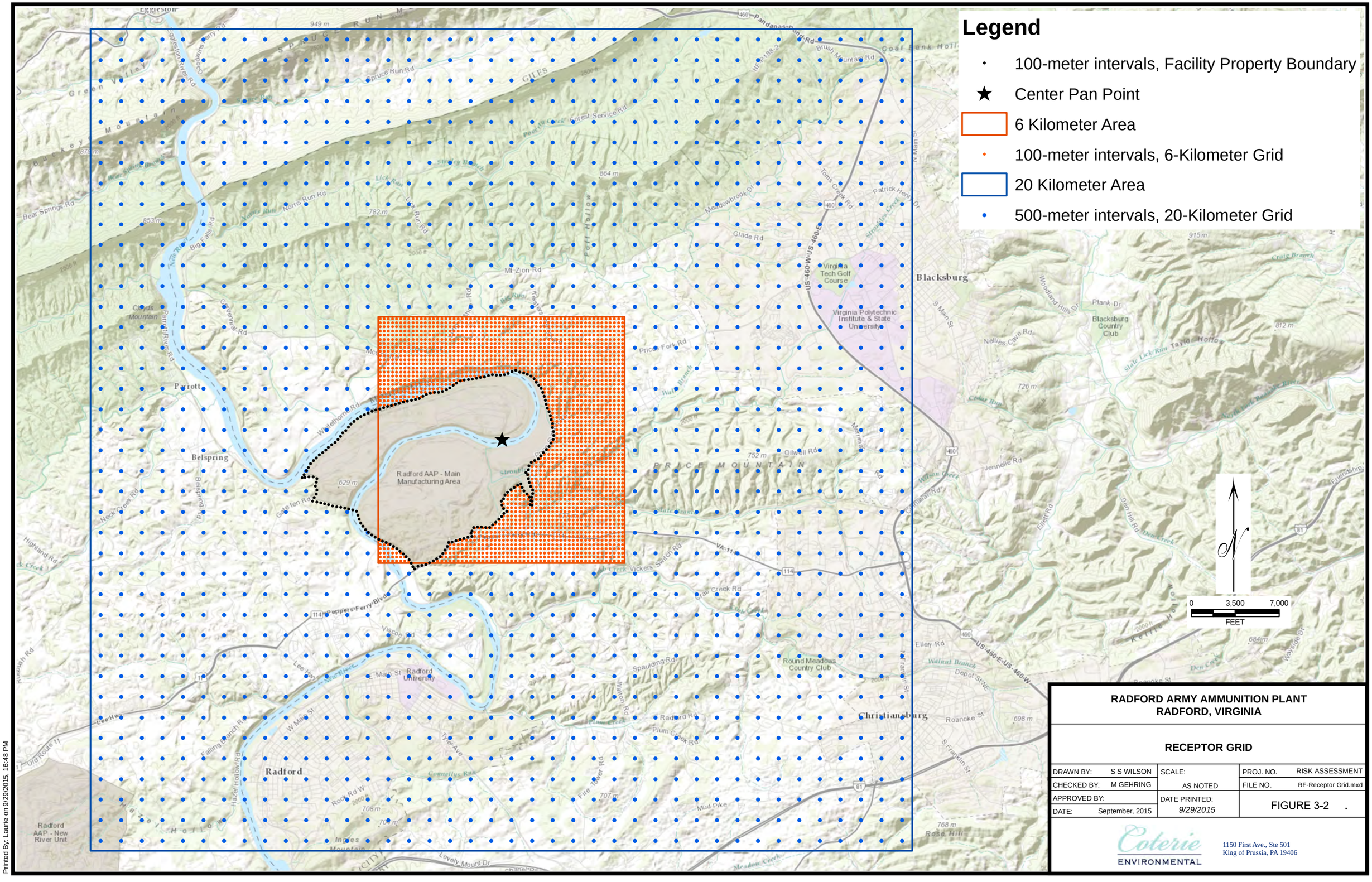
The receptor grid to be used for this analysis will follow the recommendations described in the HHRAP. The receptors will be spaced at 100-meter intervals beginning at the fenceline and extending outward to a distance of 3 km from the center of the OBG pads (UTM Coordinates 542,212E, 4,116,112N). In the region from 3 km to 10 km from the center of the OBG, the receptor spacing interval will be 500 meters. Fenceline receptors will be placed along the facility boundary at 100-meter intervals. Terrain elevations used with receptor points will be obtained from USGS Digital Elevation Models (DEMs). All coordinate locations for modeling will be converted to the North American Datum of 1927 (NAD 27). An example of the receptor grid that will be used in this MPRA is presented in Figure 3-2.

Terrain elevations of each of these receptors vary above and below the base elevation of the OBG pans, classifying the area as complex terrain. OBODM can model vapor phase concentrations in complex terrain, but is not capable of modeling particle phase concentrations in complex terrain. As a result, the vapor phase concentration will be determined using the receptors at their actual elevations; however, the particle phase concentrations will be determined assuming simple terrain, with the receptors at the same elevation at the OBG pans.

3.4 METEOROLOGICAL DATA

The meteorological data for the air model is generally a combination of two files: a surface data file and an upper air data file that are combined into one file for processing. Onsite meteorological data or National Weather Service (NWS) station data are both supported by the chosen air model. Five years of data, preferably sequential, or one-year of onsite data is recommended for a MPRA analysis. Two sets of meteorological data are required: hourly surface data and upper air (mixing height) data. The surface and upper air stations should be selected for their meteorological representativeness of the general area being modeled. Surface data may be downloaded from the USEPA SCRAM web site or from the National Data Climatic Center (NCDC). However, SCRAM data cannot be used for deposition calculations because the data does not contain the fields required to determine the type of precipitation. Data available from the NCDC, specifically, the Solar and Meteorological Surface Observation Network (SAMSON), covers the time period from 1961-1990 and does include all of the fields required to perform the deposition calculations.

For this MPRA, RFAAP will utilize meteorological data collected by the Virginia Polytechnic Institute (Virginia Tech) at the Kentland Farm. This data is recorded hourly and is available online via the Kentland Farm's website at http://www.vaes.vt.edu/college-farm. Given that this data is more recent than that available from the other sources and is more representative of site-specific conditions, RFAAP proposes to use only one year of data, treating it as onsite data, in lieu of five years of offsite data.



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RECEPTOR GRID

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DATE: September, 2015			

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Should supplemental weather data be required, it will be obtained from the Roanoke Airport (NWS Station 13741), which is located approximately 40 miles from the facility. While this location is separated from the facility by numerous terrain features and weather-influencing topographic features, it is the closest NWS station with readily available and reliable data. Upper air data for the modeling will be obtained from NWS Station 13723 (Greensboro/High Point/Winston Salem).

A USEPA program, Meteorological Processor for Regulatory Models (MPRM), version 99349, will be used to pre-process the surface and upper air data to prepare them for use in the air model. Data substitution procedures described in Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Models (Atkinson and Lee, 1992) will be consulted for filling missing data.

3.5 Model Options

When setting up the model, there are several control options that effect the way the model executes and the data it outputs. Information on each of these options is provided below.

3.5.1 Averaging Times

Because the MPRA is concerned with long-term (chronic) health risks, the averaging time in the OBODM model runs will be specified as *annual*. OBODM calculates the annual average based on the total number of hours processed and the hourly averaged concentrations, assuming that for every hour processed, an emission event occurs. Although the OBG does not operate every hour of every day, every daylight hour of every day in the meteorological file will be modeled to ensure that the model reflects the most representative meteorological conditions and does not overlook the "worst case" operating scenarios for the OBG. These annual results will then be scaled to reflect the realistic maximum number of events each year. Considering that only one burn can be conducted per day (due to safety restrictions), the actual maximum number of events per year is 365 events, rather than the 3,285 considered in the annual modeling scenario, which assumes 10 events per day (one event for every hour between 0800 and 1700 hours).

In addition to the annual average output, OBODM will be set to produce a maximum 1-hour averaged concentration for use in the acute risk analyses. In reality, the OBG is not capable of producing an emission event every hour of the day. However, modeling the emissions as such will result in a conservative maximum for the acute risk analyses.

3.5.2 Emission Partitioning

Typically, air modeling is conducted in three phases for a MPRA: vapor phase, dry deposition phase, and wet deposition phase. However, OBODM does not have the capability to calculate wet deposition. Considering that OB activities are not conducted during precipitation events, the absence of a wet deposition factor seems reasonable. The model will be run with vapor phase and dry deposition particle phase outputs only. All wet deposition inputs will be assumed to be zero.

3.5.3 Particle Size Distribution

Modeling of the particle phase deposition and air concentrations requires information on the particle size distribution of emitted pollutants. Several limited studies have been conducted on the particle size distribution of emissions from open burning events. An independent study, *Explosion Dust Particle Size Measurements* (Pinnick et. al, 1983), evaluated particles from both open and buried detonations. The BangBox studies conducted by the US Army at the Aberdeen Test Center collected data on the size distribution of emissions from various types of energetic burns. These size distributions were not affected by soil emissions. Therefore, these factors are generally accepted as the most representative distribution for open burning of energetic materials. The determined size distributions from this study are presented in Table 3-5. This same distribution has been used throughout the United States in the MPRAs for other open burning grounds, such as those at Anniston Army Depot (ANAD) in Anniston, Alabama, and the Santa Susana Field Laboratory (SSFL) in Ventura County, California. RFAAP proposes to use this particle size distribution in the OBODM modeling for the OBG.

Table 3-5
Particle Size Distribution for OBODM

Particle Diameter (μm)	Number Fraction
0.35	0.18
0.70	0.12
1.10	0.21
2.00	0.24
3.60	0.11
5.50	0.07
8.10	0.02
12.5	0.01
15.0	0.04

4.0 EXPOSURE ASSESSMENT

The purpose of this section is to discuss exposure scenarios that will likely be evaluated in the MPRA to estimate the type and magnitude of potential direct and indirect exposure to COPCs in stack emissions associated with the OBG. Identification of the exposure scenarios to be evaluated includes characterization of exposure setting, identification of potential receptors, and selection of exposure scenario parameters.

Human and ecological receptors may be exposed to COPCs in OBG emissions through two primary exposure routes:

- Directly through inhalation; or
- Indirectly through ingestion of water, soil, and vegetation and animal tissues that may have become affected by the COPCs

This section provides a characterization of the assessment area and provides a summary of the exposure scenarios that will be evaluated for the human health assessment. Information on the ecological assessment is provided in Section 7.

4.1 CHARACTERIZATION OF EXPOSURE SETTING

A characterization of the exposure setting is necessary to determine the potential human and ecological receptors and the expected types of exposure of these receptors to the constituents being evaluated in the MPRA. Such a characterization includes identifying the potential human receptors and ecological receptors and the methods for exposure to the COPCs based on both current and reasonable future human activities and land uses. To complete the characterization, surrounding populations and terrain characteristics, as well as the waterbody and watershed arrangement for an area extending 10 km from the OBG were reviewed. The following sections provide a discussion of the assessment results.

4.1.1 LAND USE AND HUMAN ACTIVITIES

RFAAP occupies approximately 4,100 acres in Pulaski and Montgomery counties in southwest Virginia. The New River separates Pulaski and Montgomery Counties and also divides the RFAAP into two portions commonly known as the Horseshoe Area and the Main Manufacturing Area. Nearby towns of Blacksburg, Christiansburg, and Roanoke serve as the primary population centers in the area. Census data from the 2010 census was reviewed to determine local population demographics. Table 4-1 presents an overview of some of this data. As shown in the table, the majority of the population in both counties consists of adults between the ages of 18 and 65. The large discrepancy between the median age in Montgomery and Pulaski counties is largely contributed to the high student population attending Virginia Tech, with nearly 30,000 students enrolled in either undergraduate, graduate, or professional

programs. In comparison, Radford University, which is located in Pulaski County, has a total enrollment of 9,743 students.

TABLE 4-1
POPULATION DEMOGRAPHICS

PARAMETER	MONTGOMERY COUNTY	PULASKI COUNTY
Total population	94,392	34,872
Persons per square mile	244	109
Median age	27 years old	44 years old
Persons under 5 years old	4.7 percent of population	4.9 percent of population
Persons under 18 years old	16 percent of population	19 percent of population
Persons over 65 years old	9.8 percent of population	18 percent of population
Male:Female Ratio	1.07	0.978
Households	35,767	14,821
Persons per household	2.38	2.29
Households with persons under 18	24 percent of households	27 percent of households
Households with persons over 65	18 percent of households	31 percent of households

Montgomery and Pulaski counties also have a diverse business profile. Table 4-2 provides a summary of the 2013 economic census data provided by the Census Bureau. As shown in the table, nearly 30 percent of Montgomery County is engaged in retail or professional, scientific, or technical services, with very limited establishments engaged in agriculture, forestry, fishing, and/or hunting. Pulaski county provides a much more even distribution of business sectors, but still shows very few businesses engaged in the agricultural sector.

TABLE 4-2
BUSINESS PROFILE

PARAMETER	MONTGOMERY COUNTY	PULASKI COUNTY
Total number of establishments	1,935	606
Agriculture, forestry, fishing, and hunting	5	2
Mining, quarrying, and oil/gas extraction	4	1
Utilities	1	3
Construction	174	48
Manufacturing	52	37
Wholesale trade	50	25
Retail trade	314	107
Transportation and warehousing	31	24
Information	41	13

TABLE 4-2 (CONTINUED)
BUSINESS PROFILE

PARAMETER	MONTGOMERY COUNTY	PULASKI COUNTY
Finance and insurance	114	36
Real estate and rental and leasing	91	22
Professional, scientific, and technical services	263	39
Management of companies and enterprises	5	2
Administration and support and waste management and remediation services	91	21
Educational services	30	3
Health care and social assistance	215	53
Arts, entertainment, and recreation	26	12
Accommodation and food services	198	68
Other services	227	88
Industries not classified	3	2

A review of the National Land Cover Data Set, aerial photographs, and local zoning maps was conducted to characterize the current and potential future land use patterns throughout the assessment area. This extensive review reveals that a large fraction (nearly 50 percent) of the area consists of deciduous, pine, or mixed forests, which are unsuitable for agricultural uses unless cleared. This grouping is followed by developed areas, which represent 36 percent of the land within assessment area. Only slightly over 10 percent of the land is currently used for agriculture.

4.1.2 TERRAIN CHARACTERISTICS

The RFAAP lies within the Ridge and Valley province of the great Appalachian Mountain region that extends from the Canadian maritime provinces south to northern Georgia and Alabama. Developed in the same Paleozoic basin as the Cumberland and Allegheny Mountains, the Ridge and Valley province was developed as the thick sedimentary deposits were extensively folded and then thrust faulted during the late Paleozoic orogeny. The ridge and valley alignments were determined by the long axes of these folds, while differential erosion of underlying bedrock formations controlled the structural development of current landforms. In this modern age, the region is characterized by long, parallel, narrow, even-crested ridges rising above intervening valleys of varying size. The linear strike-ridges are largely underlain by more resistant sandstones, quartzites, and shales, whereas the valleys are underlain by less resistant limestones, dolomites, and shales.

Much of the Ridge and Valley province lies at relatively low elevation (less than 3,000 feet mean sea level (ft MSL)), with scattered peaks along the ridges between 4,000 and 4,600 ft MSL. Within the assessment area, elevations range from approximately 1,600 ft MSL up to 2,900 ft MSL. The most

significant rise in terrain is found north to northwest of the facility along Brush and Cloyds Mountains, which are part of the Appalachian ridgeline. A second, much smaller terrain rise is seen east to southeast of the facility along Price Mountain. The RFAAP lies in a narrow valley between these ridges. Oriented in a northeast-southwest direction, the valley is approximately 25 miles long. The valley ranges from 8 miles wide at the southeast end to 2 miles wide in the northeast end. RFAAP lies along the New River in the relatively narrow northeastern corner of the valley

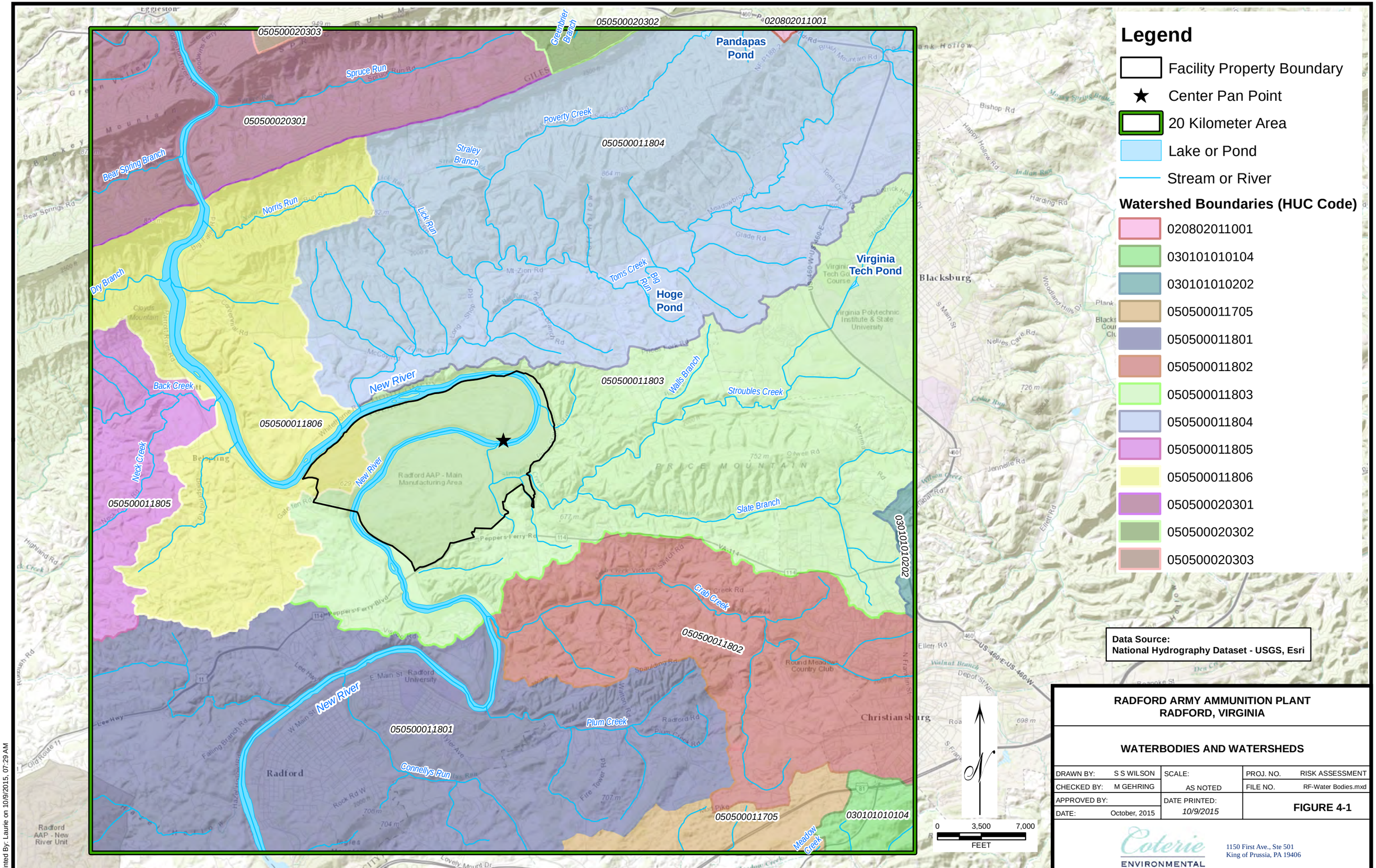
4.1.3 Waterbodies and Watersheds

The southwestern Virginia mountains in which RFAAP is located are drained by west or south-flowing streams of the Ohio and Tennessee River systems, principally the New River, the Clinch River, the Powell River, and the forks of the Holston River. The New River actually flows through the RFAAP, dividing the Horseshoe and main plant areas. The systems within the assessment area drain through 12 hydrologic units that all empty to the New River, the James River, and the Roanoke River. Table 4-3 provides a summary of each of the units and the main body of water to which they drain. Figure 4-1 provides a graphical representation of their arrangement. Because the extent of the overall drainage basins is so vast, the MPRA will only focus on the affected watersheds. A separate, discrete set of receptors will not be required to capture impact to the identified waterbodies and watersheds; the main receptor grid discussed previously provides adequate coverage. RFAAP will utilize geographic information systems to identify which receptors are within which watersheds and will determine the total impact to each watershed accordingly.

Table 4-3
Hydrologic Units and Their Drainage Basins

Hydrologic Unit	HUC 12 Code	Areal Extent (km^2) [1]	Drainage Basin
Craig Creek/Trout Creek	020802011001	0.103	Upper James River
Elliott Creek	030101010104	3.61	Upper Roanoke River
Wilson Creek	030101010202	1.33	Upper Roanoke River
Little River/Meadow Creek	050500011705	7.35	Upper New River
Connelly's Run	050500011801	74.8	Upper New River
Crab Creek	050500011802	39.2	Upper New River
Stroubles Creek	050500011803	87.0	Upper New River
Toms Creek/Poverty Creek	050500011804	91.6	Upper New River
Back Creek	050500011805	13.1	Upper New River
Dry Branch	050500011806	46.1	Upper New River
Bear Spring Branch	050500020301	33.8	Middle New River
Upper Sinking Creek	050500020302	1.58	Middle New River
Lower Sinking Creek	050500020303	0.513	Middle New River

[1] Within the assessment area.



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Some site-specific characteristics of these waterbodies and watersheds will be required for the MPRA evaluation and will be provided in the MPRA report. The following parameters will be provided for each waterbody:

- Waterbody surface area;
- Watershed surface area;
- Impervious watershed area;
- Average surface water volumetric flow rate;
- Current velocity of surface waterbody; and
- Depth of surface waterbody column.

Many of the waterbodies included in the assessment area have current fish advisories issued by the Virginia Department of Health. Fish consumption advisories are issued when fish taken from a waterbody are found to contain potentially harmful levels of contaminants. A fish consumption advisory is not a prohibition on eating fish, but instead serves as a warning about the contaminants present in fish and the potential health effects of them.

Currently, the portion of the New River and its tributaries running through Giles, Montgomery, and Pulaski counties have several active fish advisories, all of which pertain to PCB contamination in the River. These advisories, which have been issued independent of manufacturing operations at the RFAAP and result from PCB contamination provided by other sources, include:

- Carp consumption - No consumption of carp from this portion of the River is recommended; and
- Flathead and channel catfish - No more than two meals of these fish per month is recommended.

Carp are an oily, fatty fish that tend to accumulate pollutants in their fatty tissues more than other fish. Catfish are bottom feeders and therefore are more susceptible to ingestion of pollutants that accumulate in waterbody sediments. Under the current advisories, there are no recommended restrictions in other types of fish, such as bass, walleye, perch, and sunfish.

4.2 Exposure Scenarios

An exposure scenario is a combination of exposure pathways to which a single receptor may be subjected. An exposure pathway is the means by which a constituent moves from a source to a receptor. A completed exposure pathway has the following four elements:

- A constituent source and mechanism for release of the constituent;
- An environmental transport medium;
- A feasible route of potential exposure; and
- A specific point of exposure with an identified receptor.

The focus of the MPRA is to evaluate the effects that the OBG emissions will have on the health of humans residing and working offsite within the assessment area. The source of COPCs for this evaluation is emissions operation of the OBG. The potential release mechanisms associated with the source are:

- Transport of COPCs in air emissions;
- Transport of COPCs to surface soil via deposition; and
- Uptake and bioconcentration of COPCs in vegetative and animal tissues from affected soil, surface water, sediment, and air.

Regardless of the application, MPRAs rely on a basic principle that complete exposure pathways from environmental release to human or ecological exposure must exist, or health risks are not present. That is, regardless of the intrinsic toxicity of a compound, without plausible exposure opportunities, the compound will not exert its toxic effects.

4.2.1 EXPOSED RECEPTORS

The focus of the MPRA is to evaluate the effects of OBG emissions on potential offsite receptors. These offsite receptors will be identified by superimposing the deposition and concentration model outputs onto topographic and landuse maps, as well as geographic coordinates of known special subpopulations. The model results will be used to select receptor locations that represent reasonable maximum exposure to offsite receptors. Specific receptors that will be included in the human health assessment will include existing individuals living in residential areas or potential future residential areas, farming agricultural areas, fishing local waterbodies, or attending local schools, hospitals, nursing homes, and day care centers.

4.2.1.1 General Receptors

Three general receptors will be included in the MPRA:

- Adult and children residents living at the maximum impacted offsite location(s) that could allow a domicile to be established. This could include any forested area, agricultural area, or urban area within the assessment area.
- Adult and children subsistence fishers residing at the maximum impacted offsite location(s) that could allow a domicile to be established and fishing surface waterbodies with the highest modeled fish tissue concentrations in the assessment area.
- Adult and children subsistence farmers residing at the maximum impacted offsite location(s) of agricultural land use and subsisting off of homegrown produce and animal products grown and raised at this location.

Based upon a review of the land use and population demographics for the assessment area, it is highly unlikely that any subsistence farmers or fishers actually reside in the area. However, these exposure scenarios provide reasonable maximum exposure estimates for the risk calculations. If the incremental risks calculated for the theoretical subsistence farmer and subsistence fisher exceed the acceptable level, the MPRA report will include a discussion of the likelihood for these receptors to be present in the

assessment area and a discussion of the likelihood that they will conduct the activities assumed in the exposure model. Further iterations of the assessment may be performed based on more realistic produce and fish consumption rates for the area.

4.2.1.2 Special Subpopulations

In addition to the general exposure scenarios, the assessment will include an evaluation of risk to special subpopulations within the assessment area. These will include:

- Child receptors at the most impacted school and day care center;
- Adult receptors at the most impacted nursing home; and
- Child and adult receptors at the most impacted hospital.

In addition, as required by the HHRAP, an acute risk scenario will be considered. The receptor for the acute inhalation scenario will be at the offsite location with the highest one-hour average air concentration according to the model output.

4.2.2 EXPOSURE PATHWAYS

Exposure pathways typically evaluated in MPRAs for combustion facilities include:

- Inhalation;
- Ingestion of soil;
- Consumption of produce (root and above-ground);
- Consumption of beef, fish, pork, poultry and eggs;
- Consumption of dairy products;
- Consumption of drinking water; and
- Consumption of mother's breast milk.

Table 4-4 summarizes the exposure pathways that will be evaluated in the MPRA for each targeted receptor. For each pathway, the HHRAP provides standard conservative exposure assumptions that serve as a starting point for the assessment. These default exposure assumptions will be used for most pathways. However, USEPA provides for the use of site-specific information, such as land use data or area-specific intake data, if it can be demonstrated to be appropriate. This MPRA will use such site-specific data, if available and appropriate, to refine the MPRA and increase its site-specific nature. Any non-default exposure assumptions that are used will be detailed in the MPRA report.

TABLE 4-4
EXPOSURE PATHWAYS FOR TARGETED RECEPTORS

RECEPTOR	EXPOSURE ROUTES	EXPOSURE PATHWAYS	EXPOSED POPULATION
Subsistence Farmer	Inhalation, incidental soil ingestion, ingestion of homegrown food, ingestion of drinking water	Air, soil, food chain, surface water	Adult, child (1-6 yr)
Subsistence Fisher	Inhalation, incidental soil ingestion, ingestion of homegrown produce, ingestion of fish, ingestion of drinking water	Air, soil, food chain, surface water	Adult, child (1-6 yr)
Resident	Inhalation, incidental soil ingestion, ingestion of homegrown produce, ingestion of drinking water	Air, soil, food chain, surface water	Adult, child (1-6 yr)
School and daycare centers	Inhalation, incidental soil ingestion	Air, soil	Child (1-6yr), student (6-10 yr), worker (adult)
Nursing home	Inhalation	Air	Elderly (adult)
Hospital	Inhalation	Air	Child (1-6yr), elderly (adult)
Breast-feeding infant (at each general receptor)	Ingestion via breast milk	Food chain	Infant
Acute risk	Inhalation	Air	Adult, child (1-6 yr)

[1] Homegrown food includes produce, beef, milk, pork, chicken, and eggs.

4.2.2.1 General Receptors

The following exposures will be quantified for each general receptor.

- Adult and child residents will be exposed via the inhalation of COPCs in ambient air, the incidental ingestion of COPCs deposited on soil, and food chain ingestion from produce grown at the residence.
- Adult and child subsistence farmers will be exposed via the inhalation of COPCs in ambient air, the incidental ingestion of COPCs deposited on soil, and food chain ingestion from food grown at the residence (produce, beef, milk, pork, chicken, and eggs). As mentioned earlier, it appears, based on an initial evaluation, to be highly unlikely that subsistence farmers exist in the assessment area. Therefore, this is considered a very conservative scenario. If the calculated incremental risk exceeds the target risk for these receptors, the exposure pathways described for these receptors will be reevaluated based on agricultural census data, and other information that may be available to assess its applicability to the assessment area.
- Adult and child subsistence fishers will be exposed via the inhalation of COPCs in ambient air, the incidental ingestion of COPCs deposited on soil, the ingestion of fish, and the ingestion of produce grown at the residence.

4.2.2.2 Special Subpopulations

In addition to the three general exposure scenarios, the following exposures will be quantified for special subpopulations:

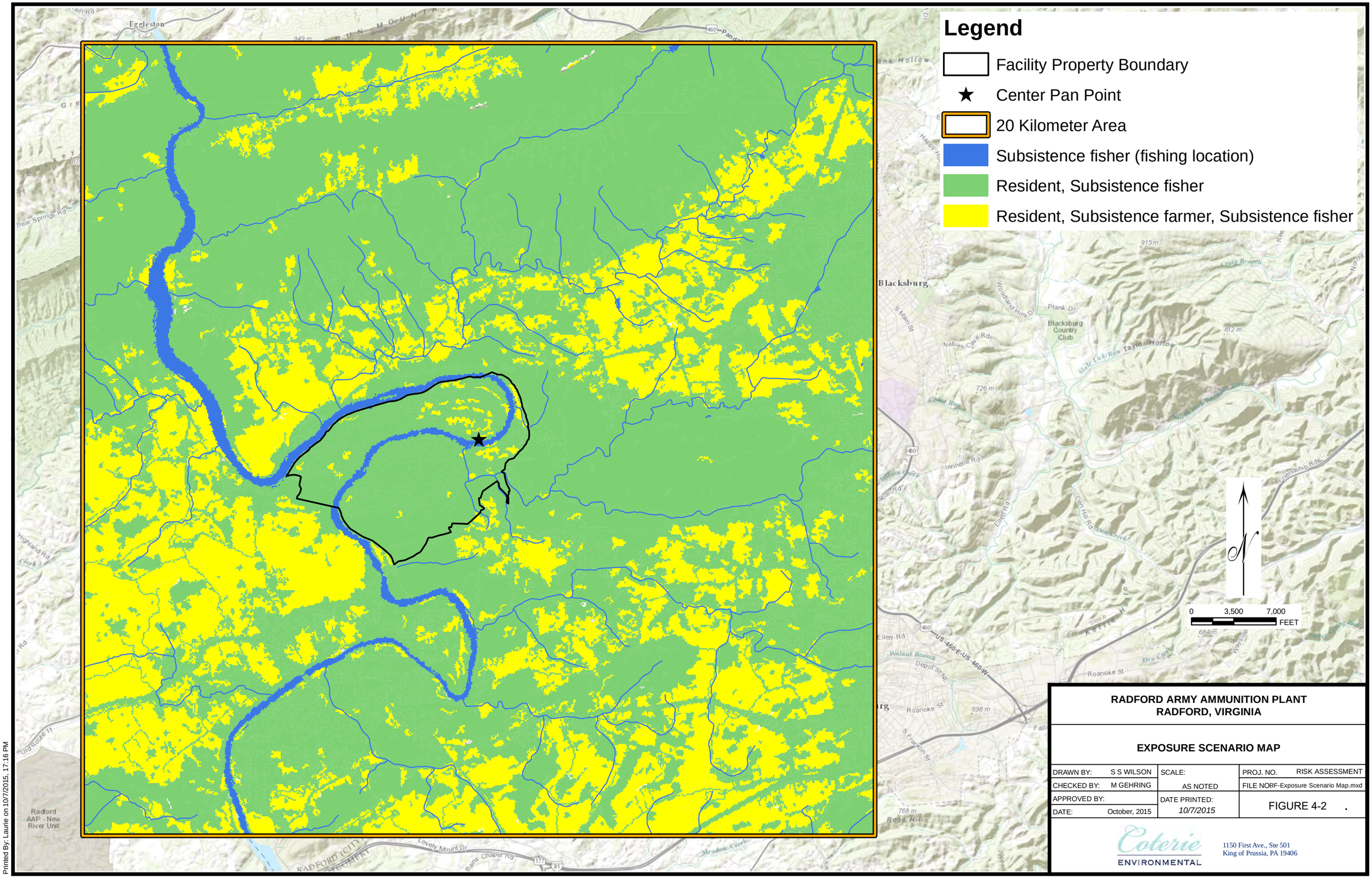
- Children and adult worker at the maximum impacted school and day care will be exposed via the inhalation of COPCs in ambient air, and the incidental ingestion of COPCs deposited on soil.
- Children and elderly at the maximum impacted hospital will be exposed via the inhalation of COPCs.
- Elderly residents at the closest nursing home will be exposed via the inhalation of COPCs.
- Infants will be exposed to D/F via the ingestion of breast milk in each of the three main exposure scenarios.
- Adult and children receptors at the offsite location with the maximum one-hour ambient air concentrations will be exposed via the direct inhalation of vapors and particulate COPCs.

4.2.3 EXPOSURE LOCATIONS

Potential locations for each exposure scenario will be identified by evaluating available land use data for the assessment area and conducting local surveillance. The land use classifications identified in the land use data will be evaluated and translated into potential receptor locations. Some locations, such as those classified as industrial or commercial, are not potential locations for residential receptors given the nature of human activities at the location. Additionally, forested areas are only considered potential receptor locations for the resident or subsistence fisher. Establishment of a subsistence farmer in these areas would involve clearing of significant portions of often forested, hilly terrain and is considered unlikely. Table 4-5 describes the translation between receptor and land use class that was used to create the exposure scenario map in Figure 4-2.

TABLE 4-5
LU/LC CLASSIFICATIONS CORRELATED TO POTENTIAL RECEPTOR LOCATIONS

LAND USE CLASS	RECEPTORS IN LAND USE CLASS
Open water	Subsistence fisher (fishing location)
Developed, open space	Resident Subsistence fisher
Developed, low intensity	
Developed, medium intensity	
Developed, high intensity	
Deciduous forest	
Evergreen forest	
Mixed forest	
Grassland/herbaceous	Resident Subsistence farmer Subsistence fisher
Hay/pasture	
Cultivated crops	



RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

EXPOSURE SCENARIO MAP

DRAWN BY: S S WILSON	SCALE:	PROJ. NO. RISK ASSESSMENT	
CHECKED BY: M GEHRING	AS NOTED	FILE NO RF-Exposure Scenario Map.mxd	
APPROVED BY:	DATE PRINTED:	FIGURE 4-2 .	
DATE: October, 2015	*10/7/2015*		

Coterie ENVIRONMENTAL
1150 First Ave., Ste 501
King of Prussia, PA 19406

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The location of each special subpopulation (*i.e.* nursing homes, day care centers, hospitals and elementary schools) will be determined through surveys of local school boards, health departments, and phone book listings and local surveillance. A preliminary list of specific exposure scenario locations is provided in Table 4-6, below. Each of these locations will be verified as still operating prior to performance of the MPRA.

TABLE 4-6
IDENTIFICATION OF SPECIAL SUBPOPULATIONS

NAME	RECEPTOR TYPE	UTM E	UTM N
Early Challenges	Day care center	551,814	4,113,560
Christiansburg Mennonite School	Day care center	551,554	4,112,542
Cedarwood Preschool	Day care center	551,554	4,112,542
Carol's Family Day care	Day care center	548,967	4,108,859
New River Community Action	Day care center	537,715	4,109,806
Central United Methodist Preschool	Day care center	538,035	4,108,889
Radford Adventure Club	Day care center	538,227	4,108,383
Ms. Wanda Harvey	Day care center	537,738	4,108,276
Radford worship Center/Rock Club	Day care center	536,571	4,107,906
Children's Garden primary	Day care center	546,497	4,118,602
The Adventure Club	Day care center	550,305	4,121,042
Valley Interfaith Childcare	Day care center	549,064	4,118,921
St. Mary's Little Angels	Day care center	547,369	4,119,377
Commonwealth Assisted Living	Nursing home	551,762	4,112,621
Commonwealth Assisted Living	Nursing home	537,356	4,110,479
Warm Hearth Village	Nursing home	551,162	4,117,325
Carillion New River Valley Hospital	Hospital	539,467	4,109,745
Montgomery Regional Hospital	Hospital	552,396	4,115,835
Gilbert Linkous Elementary	Elementary school	550,979	4,120,906
Tall Oaks Montessori	Elementary school	549,298	4,118,722
Prices Fork Elementary	Elementary school	545,459	4,118,381
Kipps Elementary	Elementary school	546,497	4,118,602
McHarg Elementary	Elementary school	538,082	4,108,443
Belle Heth Elementary	Elementary school	539,279	4,109,668
Riverlawn Elementary	Elementary school	539,477	4,110,479
Belview Elementary	Elementary school	543,347	4,113,992

4.3 QUANTIFICATION OF EXPOSURE

The air modeling described in Section 3 will generate a range of modeled COPC concentrations from the OBG based on reasonable maximum emissions for both ambient air concentrations and deposition rates. These COPC concentrations will be used to determine the exposure, or chemical intake at each receptor. For noncarcinogenic exposures, the intake is referred to as the average daily dose; for carcinogenic exposures, the intake is referred to as the lifetime average daily dose. The potential intake concentrations of COPCs for each receptor will be calculated using the exposure concentrations derived from the model.

The general formula for calculating the intake concentration is:

$$I = \frac{C_{GEN} \times CR \times EF \times ED}{BW \times AT}$$

Where:

I	=	Intake, expressed in amount/kg body weight/day
CGEN	=	COPC concentration in media of concern (*e.g.*, mg/kg in soil)
CR	=	Consumption rate, expressed in amount per day
EF	=	Exposure frequency, expressed in days per year
ED	=	Exposure duration, expressed in years
BW	=	Average body weight of receptor, expressed in kilograms
AT	=	Averaging time, expressed in days

The following sections provide more detail on how each element of the equation above will be determined for the MPRA.

4.3.1 COPC CONCENTRATIONS IN ENVIRONMENTAL MEDIA

The exposure concentrations are modeled air concentrations and deposition rates derived from input of site-specific factors into the air dispersion model. The air dispersion model is described in more detail in Section 3. Modeling output files will be included in the final report. In addition, isopleth graphs presenting air concentrations and deposition around the facility, based on a unit emission rate, will be prepared.

4.3.1.1 Air Concentrations

For selected receptor locations, the air dispersion model provides ambient air concentrations of COPCs in terms of micrograms per cubic meter (µg/m^3). These air concentrations are used directly in the calculation of inhalation intake.

4.3.1.2 Soil Concentrations

The air dispersion model will provide COPC deposition rates in terms of grams per square meter per year (g/m^2/year). For carcinogenic COPCs, the deposition rates will be converted to soil concentrations averaged over the exposure period in order to quantify risk for incidental soil ingestion and consumption of homegrown food. For noncarcinogenic COPCs, the deposition rates will be converted to soil concentrations and the highest 1-year annual average soil concentration will be used to quantify hazard resulting from COPCs in the soil. Soil concentrations will also be compared to screening values for terrestrial ecological receptors. The report will include a discussion of the assumptions and limitations of these screening values. The equations for this conversion are obtained from Volume Three of the HHRAP. The calculation assumes the following:

- Only a thin layer of soil becomes contaminated;
- This layer can be assumed to be either "tilled" - mixed to 20 centimeters, or "untilled" - mixed to one centimeter; and
- Soil residues are assumed to dissipate at a rate related to the combined effects of degradation, erosion, runoff, leaching, and volatilization.

As recommended in the HHRAP, a mixing depth of one centimeter will be used for the residence and subsistence fisher scenarios and any special subpopulations. A mixing depth of 20 centimeters will be used for the subsistence farmer scenario. For calculations dealing with surface water runoff, a mixing depth of one centimeter will be used except for areas that are tilled or likely to be tilled.

4.3.1.3 Surface Water and Sediment Concentrations

The air dispersion model will provide COPC deposition rates in terms of g/m^2/yr. Deposition rates will be converted to total water column and sediment concentrations averaged over the exposure period in order to quantify risk for fish consumption and for the ecological risk screening. The equations for this conversion are obtained from the HHRAP, Volume Three. The equations distribute deposition on the surface of the waterbody and on soil in the drainage basin to the waterbody, to the water column, and the upper benthic sediment layer. To the extent possible, site-specific or region-specific values will be used for variables in the equations. Otherwise, default values from USEPA guidance documents will be used. The effect of default variable values on the MPRA results will be discussed in the uncertainty section of the MPRA report.

4.3.2 Calculation of Intake

Average daily intake (ADI) is exposure expressed as the mass of a substance contacted per unit body weight per unit time, averaged over a period of years. The ADIs for COPCs at selected receptor locations will be calculated using the exposure equations and, where applicable, the recommended assumptions in the HHRAP, Volume Three. Both reasonable maximum exposure assumptions and central tendency assumptions will be used to calculate ADIs for the various exposure scenarios. ADI calculations, variable values, and variable value sources are presented in the HHRAP, Volume Three.

The body weight values used in the generic exposure calculation greatly affect the ADI for a given exposure pathway, as the ADI represents dose per body weight. The lighter the weight of the receptor, the greater the likely intake for that receptor. For all adult receptors, this MPRA will use a body weight of 70 kilograms, as recommended in the HHRAP. For child receptors, the MPRA will use an average body weight of 17 kilograms, as recommended in the HHRAP.

4.3.2.1 Inhalation Intake

Air concentrations calculated from the air dispersion model are used directly in the calculation of inhalation intake. The breathing rate varies with the age of the persons in each exposure scenario. The ADIs for COPCs at selected receptor locations will be calculated using the exposure equations and, where applicable, the recommended assumptions in the HHRAP, Volume Three. The average exposure time varies with the scenario.

4.3.2.2 Soil Intake

Exposure to constituents in soil occurs by direct, inadvertent ingestion of soil. The ADIs for COPCs at selected receptor locations will be calculated using the exposure equations and, where applicable, the recommended assumptions in the HHRAP, Volume Three. The quantity of incidental ingestion varies with the age of the persons in each exposure scenario. The HHRAP recommends against including dermal absorption exposure pathways in the MPRA because the resultant risks are typically small in comparison to other pathways.

4.3.2.3 Intake from Food

The subsistence farmer scenario will include consumption of homegrown fruits, vegetables, beef, pork, poultry, eggs, and milk. The subsistence fisher scenario will include consumption of homegrown fruits and vegetables and locally caught fish. The residential scenarios will include consumption of homegrown fruits and vegetables. Soil, air, surface water, and sediment concentrations will be converted to food concentrations using equations contained in the HHRAP, Volume Three. The average quantity of homegrown food consumed varies with the exposure scenario. Additionally, for each exposure scenario, infant dioxin intake from breast milk will be calculated.

4.3.2.4 Intake from Drinking Water

RFAAP maintains a database of community drinking water systems within the general vicinity of the facility. This data was compared with that collected from USEPA's Safe Drinking Water Information System (SDWIS) to identify those community water supply sources that could be impacted by emissions from the OBG. A summary of this data is provided in Table 4-7.

TABLE 4-7
SURVEY OF LOCAL DRINKING WATER SUPPLY SYSTEMS

WATER SYSTEM NAME	WATER SYSTEM ID	COUNTY	SOURCE TYPE
Belview	VA1121043	Montgomery	Surface water purchased
Bethel Area	VA1121045	Montgomery	Surface water purchased
Bethel Woods Subdivision	VA1121048	Montgomery	Ground water
Blacksburg	VA1121052	Montgomery	Surface water purchased
Christiansburg Elliston Waterline	VA1121175	Montgomery	Surface water purchased
Christiansburg	VA1121090	Montgomery	Surface water purchased
Dry Valley Subdivision	VA1121150	Montgomery	Ground water
Mudpike Road Waterline	VA1121503	Montgomery	Surface water purchased
NRV Regional Water Auth	VA1121057	Montgomery	Surface water
Parker Trailer Park	VA1121565	Montgomery	Ground water
Plum Creek	VA1121570	Montgomery	Surface water purchased
Prices Fork/Merrimac	VA1121580	Montgomery	Surface water purchased
Radford Army Ammunition Plant	VA1121643	Montgomery	Surface water
Riner Community	VA1121655	Montgomery	Ground water
Riner Mobile Home Park	VA1121005	Montgomery	Ground water
Twin Boulders Subdivision	VA1121755	Montgomery	Ground water
Vicker Heights	VA1121820	Montgomery	Ground water
Viewland Subdivision	VA1121825	Montgomery	Surface water purchased
Walton Farms Subdivision	VA1121842	Montgomery	Ground water
Woodview Subdivision	VA1121900	Montgomery	Ground water
Bellavista Estates	VA1155050	Pulaski	Ground water
Brookmont Area	VA1155055	Pulaski	Surface water purchased
Dublin Town Of	VA1155150	Pulaski	Surface water purchased
Dulaney Trailer Park	VA1155152	Pulaski	Ground water
Lakeview Waterworks	VA1155441	Pulaski	Ground water
Lakewood Estates	VA1155446	Pulaski	Ground water
Mt Olivet	VA1155505	Pulaski	Surface water purchased
Newbern Heights	VA1155521	Pulaski	Surface water purchased
Pulaski County PSA	VA1155641	Pulaski	Surface water
Pulaski, Town Of	VA1155635	Pulaski	Surface water
Riverbend Subdivision	VA1155700	Pulaski	Ground water

As shown in the table, the vast majority of water systems use ground water or surface water purchased from another location. Only three systems utilize a direct surface water withdraw:

- The New River Valley (NRV) Regional Water Authority;

- The RFAAP; and
- The Pulaski County Public Service Authority (PSA).

Of these, only the NRV Regional Water Authority and the RFAAP have intakes within the assessment area. The RFAAP intake only services onsite facilities. The Pulaski County PSA draws from water outside of the area and upstream of the facility.

Consistent with HHRAP recommendations, the ingestion of ground water will not be included as an exposure pathway in the MPRA. The ingestion of surface water from the NRV water system will be included in the assessment. A set of discrete receptors will be used to model the impact at the water supply system intake. No other waterbodies will be evaluated for the drinking water pathway.

4.3.3 Exposure Frequency and Duration

Exposure duration is the length of time, in years, that a receptor is exposed via a specific exposure pathway. Exposure frequency is the number of days in each year that the receptor is assumed to be exposed. The following assumptions regarding exposure frequency and duration for specific receptors will be used in the MPRA:

- Exposure at a residence occurs 350 days per year, 24 hours per day for each of the general exposure scenarios, based on the assumption that each individual spends at least two weeks away per year;
- The child is assumed to be in residence from ages one to six inclusive. Adults are assumed to be in residence for 30 years. Subsistence farmers are assumed to be in residence for 40 years;
- Exposure at the school and day care is assumed to occur eight hours per day, 180 days per year;
- Children are assumed to attend day care for six years, from age one through six;
- Elementary school students are assumed to attend for five years, from age six through ten;
- Adults and children at the hospital are exposed 24 hours per day for 7 consecutive days;
- Exposure at the nursing home is assumed to occur 24 hours per day, 350 days per year; and
- Elderly receptors are assumed to reside in the nursing home for three years, based on data collected from long-term care insurance providers.

5.0 TOXICITY ASSESSMENT

The toxicity assessment presents and discusses chemical-specific dose-response data for COPCs. The purpose of the toxicity assessment is twofold: 1) to review available information on potential toxic effects that may result from exposure to COPCs; and 2) to quantify the relationship between exposure to COPCs and the likelihood and severity of the potential effects. The standard references for toxic effects used for risk evaluations are presented in Appendix A-3 of the HHRAP, the USEPA Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), and the National Center for Environmental Assessment (NCEA). The most up-to-date reference doses and slope factors available at the time the risk calculations are commenced will be used. The quantification of risk will be limited to constituents with available toxicity data.

5.1 TOXICITY INFORMATION FOR NONCARCINOGENIC EFFECTS

USEPA's preferred (USEPA, 1996) toxicity value for evaluating non carcinogenic effects resulting from chemical exposure is the chronic RfD. The chronic RfD is an estimate of a daily exposure level for the human population (including sensitive populations) that should not cause an appreciable risk of harmful effects during a lifetime of exposure. For the inhalation pathway, the inhalation RfD is derived from an inhalation reference concentration, expressed in units of $\mu g/m^3$, assuming an inhalation rate of 20 cubic meters per day (m^3/day), and an average body weight of 70 kilograms. Once a complete list of COPCs has been identified for the MPRA, RFAAP will issue an addendum to this protocol that identifies the toxicity data for the MPRA.

5.2 TOXICITY INFORMATION FOR CARCINOGENIC EFFECTS

Toxicity values for constituents with potential carcinogenic effects are expressed as a CSF. The CSF is the upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is the value used to define the probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. Once a complete list of COPCs has been identified for the MPRA, RFAAP will issue an addendum to this protocol that identifies the toxicity data for the MPRA.

In addition to providing the CSF for each COPC, the addendum to this protocol will present the USEPA Weight of Evidence (WOE) for each of the COPCs that are considered by USEPA to be potential carcinogenic compounds. WOE is a classification system for characterizing the extent to which the available data indicate that an agent is a human carcinogen. The WOE classifications are as follows:

- Group A chemicals - Known human carcinogenic compounds
- Group B1 chemicals - Probable human carcinogenic compounds based on limited evidence of carcinogenicity in humans.
- Group B2 chemicals - Probable human carcinogenic compounds based on evidence of carcinogenicity in animals; human evidence is inadequate.

- Group C chemicals - Possible human carcinogenic compounds based on limited evidence of carcinogenicity in animals; human evidence is inadequate.
- Group D chemicals - Not classifiable as to human carcinogenicity.
- Group E chemicals show evidence of noncarcinogenicity in humans.

5.3 Toxicity Information for Dioxins and PAHs

The term "dioxins and furans" refers to a group of compounds more precisely called halogenated dibenzo p-dioxins and halogenated dibenzofurans. The toxicity of each congener is different and is thought to be related to its shape. The most toxic of the congeners is 2,3,7,8- TCDD. A system of TEFs has been devised to relate the toxicity of other congeners to the toxicity of 2,3,7,8-TCDD. By this method, a single risk calculation can be made that incorporates all detected congeners. Table 5-1 lists the Dioxin TEFs that were adopted by USEPA and that will be used in this MPRA. These TEFs are presented in USEPA's *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-TCDD-Like Compounds* and represent the consensus values published in 2005 by the World Health Organization (WHO).

Table 5-1
Toxicity Equivalency Factors for Dioxins and Furans

Compound	Toxicity Equivalency Factor
2,3,7,8-Tetachlorinated dibeno(p)dioxin	1
1,2,3,7,8-Pentachlorinated dibeno(p)dioxin	1
1,2,3,4,7,8-Hexachlorinated dibeno(p)dioxin	0.1
1,2,3,6,7,8-Hexachlorinated dibeno(p)dioxin	0.1
1,2,3,7,8,9-Hexachlorinated dibeno(p)dioxin	0.1
1,2,3,4,6,7,8-Heptachlorinated dibeno(p)dioxin	0.01
1,2,3,4,5,7,8,9-Octachlorinated dibeno(p)dioxin	0.0003
2,3,7,8-Tetrachlorinated dibenzofuran	0.1
1,2,3,7,8-Pentachlorinated dibenzofuran	0.03
2,3,4,7,8-Pentachlorinated dibenzofuran	0.3
1,2,3,4,7,8-Hexachlorinated dibenzofuran	0.1
1,2,3,6,7,8-Hexachlorinated dibenzofuran	0.1
1,2,3,7,8,9-Hexachlorinated dibenzofuran	0.1
2,3,4,6,7,8-Hexzchlorinated dibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorinated dibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorinated dibenzofuran	0.01
1,2,3,4,6,7,8,9-Octachlorinated dibenzofuran	0.0003

The term "PAHs" refers to a group of compounds called polycyclic aromatic hydrocarbons. Many PAHs have IRIS, HEAST, or NCEA entries for carcinogenic potency and/or noncarcinogenic toxicity. Several carcinogenic PAHs have relative potency factors (RPFs) that are related to the potency of the most toxic of the PAHs, benzo(a)pyrene. Table 5-2 lists the PAH RPFs obtained from the HHRAP that are used for this MPRA.

TABLE 5-2
RELATIVE POTENCY FACTORS FOR POLYNUCLEAR AROMATIC HYDROCARBONS

COMPOUND	RELATIVE POTENCY FACTOR
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

6.0 RISK CHARACTERIZATION

Risk characterization is the final step of the MPRA process. The risk characterization involves the integration of the exposure data and the toxicity/potency data to arrive at an expression of quantitative risk estimates for potential receptors. Consistent with USEPA guidance, the risk characterization will include a discussion of related uncertainties. These are discussed in greater detail in Section 7 of this MPRA Protocol.

Assumptions, calculations, and conclusions presented in the MPRA include uncertainties, which may arise from a variety of sources. An attempt will be made to take a reasonable and conservative approach where options exist. The MPRA report will include a discussion of factors that may lead to either an overestimation or underestimation of the potential adverse human health effects and associated environmental risks posed by site-specific conditions.

In the risk characterization, the results of the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of incremental risk for carcinogenic compounds and into a hazard index (HI) for noncarcinogenic compounds. According to Risk Assessment Guidance for Superfund (USEPA, 1989), the risk characterization is complete only when the numerical expressions of risk are accompanied by explanatory text interpreting and qualifying the results. In addition, the risk characterization presents reasonable maximum and average/central tendency exposures to site conditions in the absence of additional site controls or remediation. Hypothetical scenarios also assume no additional site controls or remediation is implemented at the property. Carcinogenic, noncarcinogenic, and acute health effects will be characterized using the equations and methodologies presented in Section 7 of the HHRAP.

6.1 NONCARCINOGENIC HAZARD INDEX ESTIMATE

The potential for chemicals to cause adverse noncarcinogenic health effects will be assessed by dividing estimated exposure doses to appropriate dose-response values, such as RfDs derived by the USEPA, using the equations defined in Appendix B of HHRAP. The resulting ratio is referred to as the "chemical-specific risk ratio" or hazard quotient (HQ). HQs for individual COPCs are summed to calculate the HI for a pathway. If multiple pathways exist in an exposure scenario, appropriate pathway HIs are added together to calculate a total HI.

The USEPA has stated that exposure to a chemical is not expected to cause significant adverse health effects if the hazard ratio, or HI, for all exposure pathways has a total value of 1.0 or less. HHRAP recommends, however, that it be assumed that 75 percent of this value be reserved for exposures that may come from other background sources, unless a facility chooses to collect background COPC concentration data before completing the MPRA. If the facility opts to not collect background data, the HHRAP indicates that the remaining HI level of 0.25 should serve as the ceiling for exposures that may

be associated with the subject facility operations. However, if further effort is undertaken to better understand the current and future background conditions and their relationship to facility emissions, a higher target level for the HI may be warranted.

For this MPRA, RFAAP opted to review Superfund Amendments and Reauthorization Act (SARA) Title III reporting data for the area to determine the other sources of contamination in the assessment area that may contribute to an increase in background concentrations. In the data review process, RFAAP determined that only a minority of the chemicals targeted for this MPRA have been reported in SARA Title III data as being released to the environment from other facilities. These chemicals, identified in Table 6-1, are released to the environment by a minimal number of sources (3). Therefore, the contribution from other sources to background contamination levels appears to be minimal and the largest background contributor (nitroglycerin) is not expected to be a driver in this MPRA.

TABLE 6-1
SUMMARY OF BACKGROUND CONTRIBUTIONS FROM OTHER FACILITIES [1]

CHEMICAL	TOTAL RELEASES (LB)			CONTRIBUTING SOURCES
	AIR	LAND	WATER	
Copper compounds	5	0	13	Grede-Radford, LLC
Diisocyanates	25	0	0	Grede-Radford, LLC
Diphenylamine	42	0	0	New River Energetics
Lead compounds	23	0	0	New River Energetics Grede-Radford, LLC
Manganese compounds	37	0	0	Grede-Radford, LLC
Nickel	2	0	0	Grede-Radford, LLC
Nitroglycerin	21,987	0	0	New River Energetics
Phenol	101	0	0	Grede-Radford, LLC
Zinc compounds	607	0	47	Electroplate-Rite Corp. Grede-Radford, LLC

[1] Source: Virginia DEQ 2013 Toxics Release Inventory Report, Appendices F and G.

Given the fact that only a minor fraction of the potential COPCs for this MPRA are released to the environment by other sources, and that the number of sources releasing these chemicals is small, RFAAP feels that the HHRAP estimate that 75 percent of the acceptable HI be reserved for background exposure or exposure from other facilities is overly conservative. As such, RFAAP recommends that the total HI from all combustion sources at the RFAAP be set at 75 percent of the recommended threshold. One half of this (0.375) will be reserved for the OBG, and the other half will be reserved for the HI from the incinerators. (The MPRA for the incinerators is discussed in a separate document). In cases where the HI exceeds the target level, a more detailed analysis will be required to determine if target levels are exceeded for specific target organs/critical effects.

6.2 Carcinogenic Risk Estimate

Potential incremental ("excess") lifetime cancer risks will be calculated for each receptor by multiplying the appropriate CSF by the site-specific exposure dose level using the equations defined in the HHRAP. Chemical-specific risks that are the result of the same exposure route are summed to give the pathway incremental risk; if multiple pathways exist in an exposure scenario, appropriate pathway risks are summed, creating the total incremental carcinogenic risk for a specific receptor population.

The USEPA has established the range of $1x10^{-4}$ to $1x10^{-6}$ as acceptable maximum limits for excess lifetime carcinogenic risks. To provide adequate protection, USEPA recommends setting a total incremental risk target at the mid-point this range ($1x10^{-5}$). A risk value of $1x10^{-5}$ indicates that for every 100,000 persons exposed to the levels determined in the MPRA, an additional one is estimated to potentially develop cancer in excess of what is normal for the population. BAE will use EPA's recommended target of $1x10^{-5}$ in this assessment. Should calculated risk exceed the target of $1x10^{-5}$, the underlying assumptions and default variable values used in the risk calculations will be reviewed and modified, if warranted.

6.3 Acute Hazard Assessment

In addition to chronic risks, those risks resulting from acute exposures to COPCs will also be evaluated. The highest one-hour values will be calculated for all COPCs. HHRAP recommends comparing these maximum one-hour concentrations to acute inhalation exposure guidelines. HHRAP describes a hierarchical approach to identifying acute criteria for this evaluation. Acute criteria were identified from several different sources and were ranked in order of preference according to whether they protected "general public" exposures (versus occupational exposures) and the level of documentation and review. The hierarchical procedure described in HHRAP will be used to identify acute inhalation criteria. Potential risk from acute inhalation exposure will then be estimated by comparing the estimated maximum one-hour concentration to the acute criteria. The cumulative target level for the evaluation of acute inhalation exposure is specified in HHRAP as a value of 1.0.

6.4 Risk-Based Emission Target Concentrations

If calculated risks or hazard exceed the acceptable risk range after careful consideration of all variables and uncertainties in the risk estimation process, emission target concentrations will be calculated that bring the calculated risks and hazards within the acceptable range. These target concentrations will be used to determine OBG constituent loadings that present acceptable risk and will be presented in the MPRA report.

7.0 ECOLOGICAL RISK ASSESSMENT

RFAAP is proposing to use a two-phased approach for the ecological risk assessment (ERA). Phase I of the ERA will focus on a semi-quantitative analysis, thru the comparison of expected soil, surface water and sediment concentrations to accepted ecological benchmarks. If the results of Phase I indicate that media concentrations resulting from the OBG emissions exceed published ecological benchmarks, two options will be pursued. If acceptable protection can be provided through limiting constituents in the OBG waste feed without significantly reducing operating flexibility, such limits will be proposed. If this is not possible, a more in-depth "Phase II" ecological risk analysis will be conducted. This assessment would be conducted using guidance contained in the USEPA's SLERA, Guidelines for Ecological Risk Assessment, and Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. This protocol provides the procedures to be used for a Phase I assessment. Prior to performing the Phase II assessment, RFAAP will submit a site-specific ERA protocol that details the planned Phase II assessment.

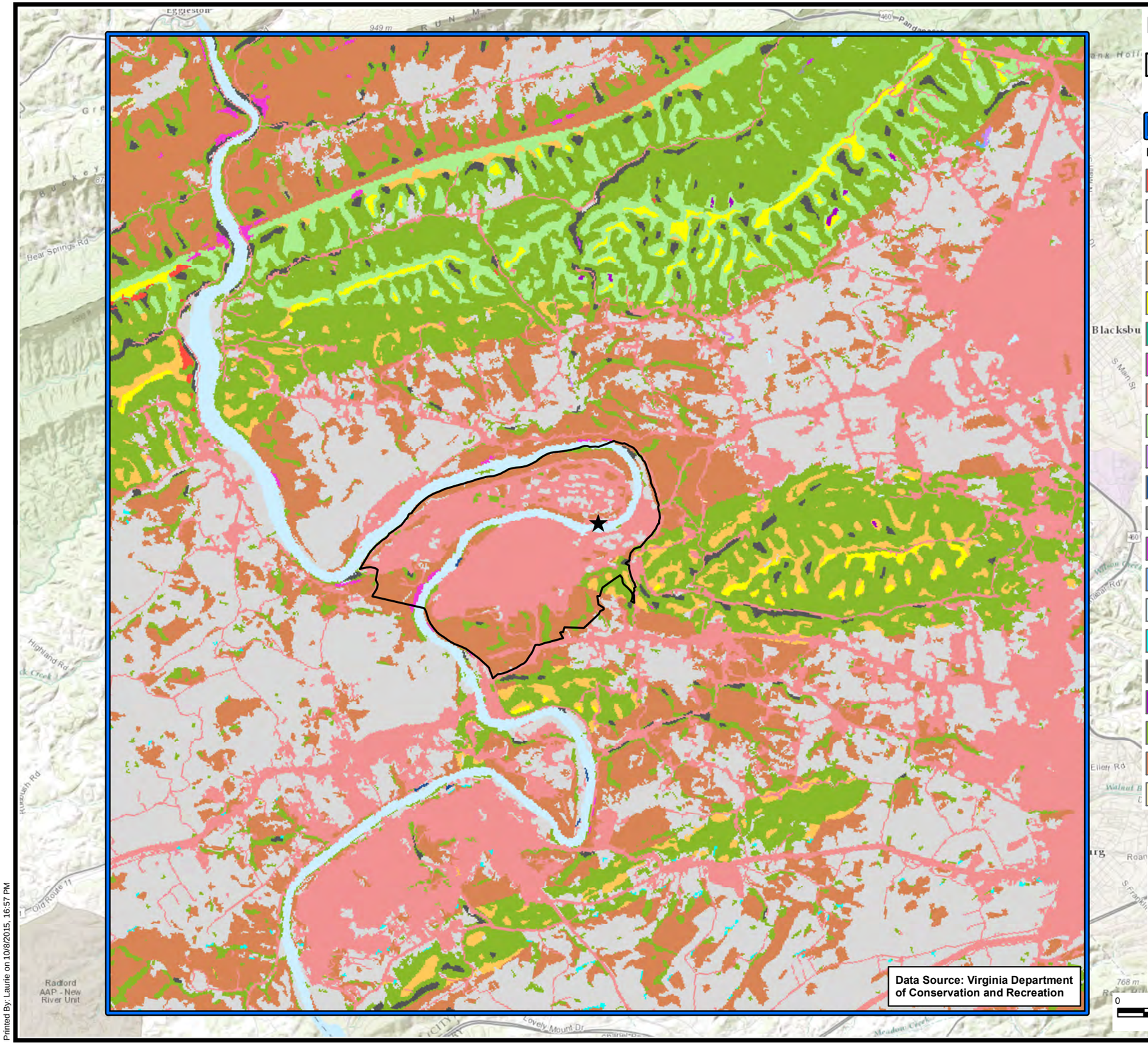
7.1 ECOLOGICAL CHARACTERIZATION

As part of characterizing the nearby ecological communities, it is important to identify significant ecological habitats and to determine if any special ecological species, such as threatened and endangered species, exist within the assessment area. Habitat selection and receptor identification are discussed in the following sections.

7.1.1 ECOLOGICAL HABITATS

As discussed in Section 1, the surrounding land use is supportive to a wide variety of plant and animal communities. The state is located geographically such that it is a meeting ground of northern and southern flora and fauna. The presence of a wide diversity of regional and topographical vegetation sequences supports a diverse animal population.

Within the assessment area, RFAAP identified potential terrestrial habitats, including primarily forested and agricultural habitats, and potential aquatic habitats, including freshwater lakes, streams, and marshes and wetlands. Figure 7-1 provides a map of the various habitats that were identified. Table 7-1 provides a distribution of the top 99 percent of the habitats within the assessment area. The remaining 13 habitats represent less than 1 percent of the assessment area. While these will be considered for special or critical habitat review, the primary focus of the screening assessment will be those 8 that represent over 99 percent of the area.



Legend

- Facility Property Boundary
- Center Pan Point
- 20 Kilometer Area

HABITAT

- Acidic Cliff and Talus
- Agriculture
- Allegheny-Cumberland Dry Oak Forest and Woodland
- Appalachian (Hemlock)-Northern Hardwood Forest
- Central Appalachian Pine-Oak Rocky Woodland
- Central Interior Highlands and Appalachian Sinkhole and Depression Pond
- Circumneutral Cliff and Talus
- Developed
- Dry Oak-Pine Forest, Central Apps and Southern Piedmont
- Laurentian-Acadian Freshwater Marsh
- Laurentian-Acadian Large River Floodplain; North-Central Appalachian Large River Floodplain; North-Central Interior Large River Floodplain; Piedmont-Coastal Plain Large River Floodplain
- Laurentian-Acadian Wet Meadow-Shrub Swamp
- North-Central Appalachian Acidic Swamp
- North-Central Interior and Appalachian Rich Swamp
- Open water
- Shrubland/grassland; mostly ruderal shrublands, regenerating clearcuts
- Southern and Central Appalachian Cove Forest
- Southern Appalachian Montane Pine Forest and Woodland
- Southern Appalachian Oak Forest
- Southern Ridge and Valley / Cumberland Dry Calcareous Forest
- Southern Ridge and Valley Calcareous Glade and Woodland

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

HABITATS

DRAWN BY: S S WILSON	SCALE:	PROJ. NO.	RISK ASSESSMENT
CHECKED BY: M GEHRING	AS NOTED	FILE NO.	RF-Habitat.mxd
APPROVED BY:	DATE PRINTED:	FIGURE 7-1	
DATE: October, 2015	*10/8/2015*		

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King of Prussia, PA 19406

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TABLE 7-1
HABITAT DISTRIBUTIONS WITHIN THE ASSESSMENT AREA

HABITAT TYPE	CATEGORY	PERCENTAGE
Agriculture	Terrestrial	29.3%
Southern Appalachian Oak Forest	Terrestrial	21.7%
Developed	Terrestrial	20.0%
Southern Ridge and Valley/ Cumberland Dry Calcareous Forest	Terrestrial	18.6%
Dry Oak-Pine Forest, Central Appalachians and Southern Piedmont	Terrestrial	3.91%
Open Water	Aquatic	2.31%
Allegheny-Cumberland Dry Oak Forest and Woodland	Terrestrial	1.94%
Southern and Central Appalachian Cover Forest	Terrestrial	1.12%

7.1.2 POTENTIAL ECOLOGICAL RECEPTORS

A preliminary review was conducted to identify especially sensitive ecological receptors that may be present within the assessment area. Data from 1998 and 2013 biological surveys at the RFAAP was used in conjunction with data available from NatureServe Explorer (http://explorer.natureserve.org) and the United States Fish and Wildlife Information for Planning and Conservation (IPaC) resource list. There were several listed endangered and threatened species, birds of conservation concern, and wetlands identified within the assessment area. There were no critical habitats or national wildlife refuges in the area. Table 7-2 provides an overview of those endangered, threatened, and imperiled species within the assessment area. The tables in Appendix A provide a complete list of the ecological species identified in the area and the conservation status of them.

TABLE 7-2
ENDANGERED, THREATENED, AND IMPERILED SPECIES

SCIENTIFIC NAME	COMMON NAME	STATUS	LOCATION (COUNTY)
A Cave Beetle	Other beetles	Critically imperiled	Pulaski
A Cave Dipluran (Salamander Cave)	Diplurans, springtails, and proturans	Critically imperiled	Giles
A Cave Springtail	Diplurans, springtails, and proturans	Imperiled	Giles
A Dipluran	Diplurans, springtails, and proturans	Imperiled	Montgomery, Pulaski
A Ground Beetle	Other beetles	Imperiled	Montgomery
A Millipede	Millipedes and centipedes	Imperiled	Giles, Montgomery
Addison's Leatherflower	Flowering plants	Critically imperiled	Montgomery

TABLE 7-2 (CONTINUED)
ENDANGERED, THREATENED, AND IMPERILED SPECIES

SCIENTIFIC NAME	COMMON NAME	STATUS	LOCATION (COUNTY)
Appalachian Grizzled Skipper	Butterflies and skippers	Critically imperiled	Montgomery
Bentley's Coralroot	Flowering plants	Imperiled	Giles
Big Sandy Crayfish	Crayfishes	Imperiled	Giles
Canby's Mountainlover	Flowering plants	Imperiled	Giles, Montgomery, Pulaski
Ephemeral Cave Amphipod	Amphipods	Critically imperiled	Giles
Henrot's Cave Isopod	Isopods	Imperiled	Giles, Pulaski
Indiana Myotis	Bats	Listed endangered	Giles, Montgomery
James Cave Amphipod	Amphipods	Imperiled	Giles, Pulaski
James Spinymussel	Freshwater mussels	Listed endangered	Giles
Jefferson's Short-nosed Scorpionfly	Other insects	Imperiled	Giles
Mitchell's Satyr Butterly	Butterflies and skippers	Listed endangered	Pulaski
Orangefin Madtom	Freshwater and anadromous fishes	Imperiled	Montgomery
Peters Mountain Mallow	Flowering plants	Listed endangered	Giles
Roanoke Logperch	Freshwater and anadromous fishes	Listed endangered	Montgomery
Smooth Purple Coneflower	Flowering plants	Listed endangered	Montgomery, Pulaski
Spotted Cave Beetle	Other beetles	Imperiled	Giles
Straley's Cave Beetle	Other beetles	Critically imperiled	Giles
Swordleaf Phlox	Flowering plants	Imperiled	Montgomery, Pulaski
Torrey's Mountainmint	Flowering plants	Imperiled	Giles
Virginia Coil (fringed mountain snail)	Terrestrial snails	Listed endangered	Pulaski

7.2 ECOLOGICAL COPC SELECTION

An objective of the initial steps of the ERA process is the identification of ecological COPCs. Ecological COPCs are those site-related constituents that have the greatest potential to cause adverse effects to the environment. In the case of hazardous waste combustion facilities, those constituents that have been identified in the combustion emissions and other constituents likely to be present in the unit emissions based on the characteristics of the facility are designated as the COPCs. The method for selecting COPCs and COPC classes that will be considered for this MPRA were identified and discussed in Section 2. However, not all of the potential COPCs have ecological criteria available and, therefore, cannot be included in a quantitative evaluation. Once a complete list of COPCs for the MPRA is established, RFAAP will issue an addendum to this protocol that provides the available ecological benchmarks for each COPC. Any COPCs without ecological exposure criteria will be discussed in the uncertainty analysis provided in the MPRA report.

7.3 PHASE I ECOLOGICAL ASSESSMENT

In the Phase I ERA, ecological risk will be evaluated semi-quantitatively by comparing soil, surface water, and sediment COPC concentrations calculated from model deposition outputs to published ecological benchmarks. These benchmarks will be obtained from data published by the USEPA, the Oak Ridge National Laboratories, and other sources, as appropriate. These ecological benchmarks are conservative COPC-specific values that represent known constituent concentrations that are protective of the environment. In many instances, the benchmarks are based on the lack of adverse toxicological effects on the most sensitive of species. COPCs without a published ecological screening benchmark will be evaluated qualitatively in light of the absence of available toxicity information.

During the Phase I ERA, the list of sensitive ecological receptors (Table 7-1) will be refined to determine which of those identified are likely to have a home range within the assessment area. These receptors will be given special consideration in all phases of the ERA.

The highest soil, sediment, and surface water concentrations within an identified habitat for an ecological receptor will be used for comparison to the ecological benchmarks. If calculated COPC concentrations exceed published ecological benchmarks, the assumptions of the COPC calculation will be reassessed. If benchmarks continue to be exceeded, the Phase II screening ERA will be performed.

7.4 PHASE II ASSESSMENT

The Phase II ERA will only be initiated if the results from the Phase I ERA indicate the potential for significant ecological impact or harm exists and these risks cannot be mitigated with feed rate controls. In the Phase II ERA, specific ecological receptor locations will be based on the location within the habitat with the highest modeled air parameters (i.e. air concentration, dry deposition rate and wet deposition rate). The Phase II ERA will include the following stages:

- Problem formulation,
- Analysis, and
- Risk characterization.

The following sections provide a brief overview of this process. If a Phase II ERA is deemed necessary, a separate protocol detailing the planned assessment will be submitted for DEQ's review.

7.4.1 PROBLEM FORMULATION

The problem formulation stage will include the integration of available information on the COPCs, the characterization of the environments that will be evaluated, and the exposure opportunities (pathways) present at these locations. From this, RFAAP will develop a site-specific migration and exposure model and a plan for how the analysis will proceed. Portions of this stage, including the integration of COPC information, and the ecological setting characterization will be completed as part of the Phase I ERA.

7.4.2 ANALYSIS

The second stage of the Phase II ERA, the analysis stage, will include the exposure and toxicity assessment. As part of this stage, the routes of exposure for a given ecological receptor to a COPC will be evaluated. Once the exposure routes have been determined, and the resulting exposure to the measurement receptor has been quantified, the toxicity of each COPC via each identified exposure route will be determined. The results of this stage will feed the risk characterization that completes the Phase II ERA.

7.4.3 RISK CHARACTERIZATION

The third and final stage of the Phase II ERA is the risk characterization stage. At this point, the exposure assessment data and toxicity assessment data are combined to determined the risk that would result from exposure of a specific ecological receptor to each COPC. Not only will risk be quantified in this stage of the Phase II ERA, but the magnitude and nature of the potential risk, as well as the significance of the risk results will be described.

The quantified risk will be compared to target levels. ERA is a relatively new process in hazardous waste combustion permitting. There are no definitive guidelines for the ecological target levels. If a Phase II ERA is required, RFAAP will work with DEQ to establish the target levels prior to commencing the assessment.

8.0 UNCERTAINTY ANALYSIS

The methodologies utilized in the MPRA are complex and involve the integration of numerous algorithms that are intended to simulate the release of pollutants into the environment, the fate and transport of those pollutants through environmental media, and the potential of adverse health effects that may result from human exposure to the pollutants. Inherent in all of these evaluations are varying degrees of uncertainty. This section provides a discussion on those uncertainties and provides information on how they will be handled in the MPRA report.

8.1 TYPES OF UNCERTAINTY

Uncertainty in the MPRA can result from various sources, including:

- The use of conservative assumptions and estimated variable values;
- The application of emission factors established using non site-specific data during limited testing events;
- The application of air dispersion models with limited accuracy;
- The utilization of theoretical and experimentally-based fate and transport equations; and
- The use of USEPA toxicity values, some of which are derived from animal studies, that have low confidence ratings and high uncertainty factors (UFs).

When combined, these compounded uncertainties result in a conservative estimate of risk. Unfortunately, the degree of conservatism in risk estimates cannot be measured; however, the assumptions combine many conservative factors and are likely to overestimate actual exposure. A discussion of how each of these sources of uncertainty may affect the MPRA, and how this uncertainty will be addressed in the MPRA report is provided below.

8.1.1 ASSUMPTIONS AND VARIABLE VALUES

In the absence of empirical or site-specific data, assumptions and variable values are developed based on best estimates of exposure or dose-response relationships. To assist in the development of these estimates, USEPA recommends the use of guidelines and standard factors in MPRAs (USEPA, December 1989 and March 1991). The use of these standard factors is intended to promote consistency among risk evaluations where assumptions must be made. Although the use of standard factors undoubtedly promotes comparability, their usefulness in accurately predicting risk is directly proportional to their applicability to actual site-specific conditions.

The initial MPRA will use many default assumptions and variable values. Many of these values are considered overly conservative for some applications; however, the time needed to develop site-specific factors can be extensive and is not always necessary. Therefore, if the results for the initial MPRA present overly conservative estimates of risks, default values will be replaced with more site-specific

values. This approach will help to decrease uncertainty in the MPRA and will lead to a more accurate depiction of the actual risk and hazard expected to result from facility emissions. Any non-default assumptions employed in the MPRA, and not specified in this protocol, will be explained and justified in the MPRA report.

8.1.2 Emission Sampling and Estimating Methods

The ability to accurately sample emissions from open burning remains challenging. While USEPA is advancing research to allow collection of more representative and more accurate samples, this research is still in the early stages. Old emission estimating methods have been based on studies conducted by the DOE at a test site. These "bang-box" emission factors were not generated from RFAAP waste materials. If used, the factors will introduce uncertainty in that regard. Factors will be selected from tests that best approximate the RFAAP material. However, without direct emission factors from RFAAP material, the estimates will only provide an approximation of emissions.

8.1.3 Air Modeling Methods

Although air dispersion modeling is a valuable tool for estimating concentration and deposition impacts, it has many limitations. The accuracy of the model is limited by the ability of the model algorithms to depict atmospheric transport and dispersion of contaminants, and the accuracy and validity of the input data. For instance, most refined models require input of representative meteorological data from a single measuring station, while in reality, a release will encounter highly variable meteorological conditions that are constantly changing as it moves downwind.

In addition, the OBODM model, while the best available for approximating emissions from open burning, has many limitations. For example, the model does not incorporate wet deposition algorithms and cannot model particle phase emissions in complex terrain.

8.1.4 Fate and Transport Equations

The HHRAP provides numerous equations to determine the fate and transport of pollutants through environmental media, and the impact that those pollutants have on the exposed population. These equations were developed from what USEPA determined to be the best-available information at the time the HHRAP was published. Unfortunately, these equations are based on either theoretical assumptions, experimentally determined relationships, or undetermined sources. Therefore, each equation employed has uncertainty associated with it. As with the other sources of uncertainty, when the uncertainties associated with each equation are compounded, the resultant risk determinations are highly conservative.

The ability of RFAAP to eliminate the uncertainties resulting from use of the recommended fate and transport equations is highly limited, unless alternative equations are used. At this time, RFAAP does not intend to employ fate and transport equations other than those provided in the HHRAP. USEPA has attempted to identify the uncertainties associated with each equation to the best extent possible in the

Appendices to the HHRAP. The MPRA report will include a discussion on these recognized uncertainties, as well as any other uncertainties that RFAAP may identify.

8.1.5 Toxicity Values

The determination of risk and hazard associated with a given pollutant is based largely on toxicity values recommended by USEPA. This MPRA will obtain most of these values from USEPA's IRIS database. Even though the database values are reviewed and updated frequently by various USEPA work groups, each value has varying degrees of confidence and uncertainty associated with it. USEPA ranks the confidence level of the source study, the study database, and the derived risk factor on a three point scale: low, medium and high. Using values with low confidence ratings increases the uncertainty in the MPRA. Also, each risk factor has an associated UF that allows for interspecies extrapolation, sensitive population protection, database deficiencies, and subchronic to chronic extrapolation. These UFs, which work as multipliers, can range from low (e.g. 10) to high (e.g. 3,000).

In this MPRA, RFAAP will utilize the most up-to-date toxicity values for each pollutant with preference given to those values presented in the IRIS database. Other sources for toxicity values include USEPA's HEAST database and the HHRAP, Appendix A.

8.1.6 Food Web Exposure Modeling

Chemical concentrations in ecological food webs will be derived from modeled media concentrations and these concentrations will then be compared to ecological benchmarks. The use of generic, literature-derived exposure models and bioaccumulation factors in determining these concentrations introduces uncertainty. Furthermore, assuming that any chemical is 100 percent bioavailable for food web uptake is a significant over estimate that introduces additional uncertainty. The modeling also does not take into account the effect of chemical mixtures on ecotoxicty. This information is lacking for most chemicals. Instead, a compound-by-compound comparison is made and an aggregate exposure is then evaluated for those COPCs that have ecological benchmarks available.

8.2 Risk Assessment Uncertainty Analysis

In order to make an attempt at characterizing the uncertainty from the MPRA, RFAAP will include an uncertainty analysis in the MPRA report. The primary goal of the uncertainty analysis will be to provide a discussion of the key assumptions used in the risk evaluation that most significantly influence the estimate of risk. A discussion of the sources of uncertainty contributing to the risk and the associated effects of these factors (overestimation or underestimation of risk) will be included in the uncertainty discussion in the MPRA report and will reflect current written USEPA guidance. A summary table will be included in the report that lists the key assumptions associated with emissions monitoring, air modeling, exposure assessment, toxicity evaluation, and characterization. The table will include the rationale for those assumptions, their effect on estimates of risk (overestimation, underestimation, neutral), and the magnitude of the effect (high, medium, low).

9.0 MULTIPATHWAY RISK ASSESSMENT REPORT

The MPRA report will address each of the eight tasks required to complete a MPRA. These eight steps, as presented in Figure 1-1 of the HHRAP include:

- Facility Characterization
- Air Dispersion and Deposition Modeling
- Exposure Scenario Selection
- Estimation of Media Concentrations
- Quantifying Exposure
- Risk and Hazard Characterization
- Uncertainty Interpretation
- Conclusions and Recommendations

A complete copy of the MPRA report and all supporting calculations and modeling data will be provided to DEQ upon completion of the assessment.

10.0 REFERENCES

Anniston Army Depot-CH2MHill. September 2007. Air Modeling and Risk Assessment for the Open Burning Unit, Open Detonation Unit, and Confined Detonation Chamber.

Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies. JAM, Vol. 17, pp. 636-643.

Bjorklund, J.R. et al. 1998. Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide Volume I, User's Instructions. West Desert Test Center, U.S. Army Dugway Proving Ground, Dugway, Utah.

California Environmental Protection Agency (CalEPA). Office of Environmental Health Hazard Assessment. October 1998. Technical Support Document for the Determination of Acute Reference Exposure Levels for Airborne Toxicants.

Chromate Toxicity Review Committee (CTRC). August 2001. Scientific Review of Toxicological and Human Health Issues Related to the Development of a Public Health Goal for Chromium(VI).

NatureServ Explorer. September 2015. 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Pinnick, R.G., Fernandez, G., and Hinds, B.D. January 1983. *Explosion Dust Particle Size Measurements*. Applied Optics, Volume 22, Issue 1, pp. 95-102.

Radford University. September 2013. Animal Surveys at the Radford Army Ammunition Plant, 2012-2013.

RFAAP-CH2MHill. June 2003. Air Modeling Protocol for the Open Burning Ground, Radford Army Ammunition Plant.

RFAAP-CH2MHill. April 2003. Human Health Risk Assessment Protocol for the Open Burning Ground, Radford Army Ammunition Plant.

RFAAP-CH2MHill. July 2004. Screening Level Ecological Risk Assessment Protocol for the Open Burning Ground, Radford Army Ammunition Plant.

RFAAP-CH2MHill. September 2005. Human Health Risk Assessment for the Open Burning Ground, Radford Army Ammunition Plant.

RFAAP-CH2MHill. September 2005. Screening Level Ecological Risk Assessment for the Open Burning Ground, Radford Army Ammunition Plant.

United States Census Bureau (USCB). 2013. State and County *QuickFacts* for Montgomery and Pulaski Counties, Virginia. Available at http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

USCB. 2013. County Business Patterns for Montgomery and Pulaski Counties, Virginia. Available at http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

USEPA. October 2015. Integrated Risk Information System.

USEPA. December 2010. Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-TCDD-Like Compounds. EPA/100/R 10/005.

USEPA. July 2009 and updates. AP-42 5th Edition, Chapter 15, Ordnance Detonation.

USEPA. February 2002. Open Burning/Open Detonation Permitting Guidelines. Prepared by Tetra Tech, Inc., Draft Final.

USEPA. August 1999a. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities: Errata. Transmitted in a Memorandum from Barnes Johnson, Director, Economics, Methods and Risk Analysis Division, USEPA.

USEPA. August 1999b. Screening Level Ecological Risk Assessment for Hazardous Waste Combustion Facilities. USEPA/530/C-99/004.

USEPA. August 1998. Guidance on Collection of Emissions Data to Support Site-Specific Risk Assessments at Hazardous Waste Combustion Facilities. USEPA530-D-98-002.

USEPA. July 1998a. Region 6 Risk Management Addendum - Draft Human Health Protocol for Hazardous Waste Combustion Facilities. EPA R6-98-002.

USEPA. July 1998b. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. USEPA530-D-98-001A-C.

USEPA. April 1998. Guidelines for Ecological Risk Assessment. USEPA/630/R-95/002F.

USEPA. April 1998. Superfund Exposure Assessment Manual. USEPA/540/1-88/001, OSWER Directive 9285.5-1.

USEPA. July 1997. Health Effects Summary Tables (HEAST). Annual FY 1997. USEPA 540/R-97-036, 9200.6-303(97-1), PB97-921199.

USEPA. June 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. EPA 540 R 97 006.

USEPA. May 1997. Model Parameter Sensitivity Analysis. Region 6 Center for Combustion Science and Engineering.

USEPA. December 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil.

USEPA. November 1994. Strategy for Hazardous Waste Minimization and Combustion. EPA 530-R-94-044.

USEPA. 1994. Health Assessment Document for 2,3,7,8-TCDD and Related Compounds. Volume III. Review Draft. EPA 600-BP-92-001c.

USEPA. March 1991. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final. OSWER Directive 9285.6-03.

USEPA. December 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final. EPA 540-1-89-002.

USEPA. July 1989. Exposure Factors Handbook. USEPA/600/8-89/043.

USEPA. April 1981. Regional Workshop on Air Quality Modeling: A Summary Report. EPA 450-4-82-015.

USEPA. Guidelines on Air Quality Models. 40 CFR Part 51, Appendix W.

United States Fish and Wildlife Service. September 2015. IPaC Trust Resource Report.

USGS. October 2015. National Land Cover Dataset for Virginia.

USGS-Esri. October 2015. National Hydrography Dataset.

Virginia Department of Conservation and Recreation. October 2015. Habitat Data for Montgomery and Pulaski Counties.

Virginia Department of Game and Inland Fisheries. 1998. Biological Survey of RFAAP Including Threatened, Endangered, and Species of Concern.

Appendix A:
ECOLOGICAL SPECIES WITHIN THE ASSESSMENT AREA

Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species and their Habitats - Montgomery County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
A Beetle	***Atheta annexa***	Insects	Beetles	G4			US: AL, IN, VA				
A Dipluran	***Litocampa sp. 3***	Diplurans, Springtails and		G2			US: VA				
A Geometrid Moth	***Euchlaena milnei***	Insects	Butterflies and Moths	G2G4			US: IL, NC, OH, VA, WI, WV	Forest - Hardwood			
A Ground Beetle	***Pseudanophthalmus pusio***	Insects	Beetles	G2G3			US: VA				
A Mayfly	***Tsalia berneri***	Insects	Mayflies	G4			US: GA, NC, SC, TN, VA				
A Millipede	***Pseudotremia cavernarum***	Millipedes and Centipedes		G2G3			US: VA				
A Noctuid Moth	***Dichagyris grotei***	Insects	Butterflies and Moths	G4			US: IN, PA, VA, WI CA: AB				
Addison's Leatherflower	***Clematis addisonii***	Flowering Plants	Buttercup Family	G1?			US: VA	Forest - Mixed Forest/Woodland			
Alderleaf Buckthorn	***Rhamnus alnifolia***	Flowering Plants	Buckthorn Family	G5			US: CA, CT, IA, ID, IL, IN, KY, MA, ME,				
American Purple Vetch	***Vicia americana ssp. americana***	Flowering Plants	Pea Family	G5T5			US: AK, AZ, CA, CO, IA, ID, IL, IN, KS,				
American Purple Vetch	***Vicia americana***	Flowering Plants	Pea Family	G5			US: AK, AZ, CA, CO, DC, IA, ID, IL, IN, KS,				
Appalachian Grizzled Skipper	***Pyrgus wyandot***	Insects	Butterflies and Moths	G1G2Q			US: DC, MD, MI, NC, NJ, NY, OH, PA, VA,	Cliff Forest - Hardwood			
Arogos Skipper	***Atrytone arogos***	Insects	Butterflies and Moths	G3			US: AL, AR, CO, FL, GA, IA, IL, KS, LA,	Grassland/herbaceous Old field	Bog/fen		
Brown-eyed-Susan	***Rudbeckia triloba***	Flowering Plants	Aster Family	G5			US: AL, AR, CO, CT, DC, DE, FL, GA, IA,				
Canada Anemone	***Anemone canadensis***	Flowering Plants	Buttercup Family	G5			US: CO, CT, DC, IA, IL, IN, KS, KY				
Canby's Mountain-lover	***Paxistima canbyi***	Flowering Plants	Bittersweet Family	G2			US: KY, MD, NC, OH, PA, TN, VA, WV	Barrens Cliff			
Cooper's Milkvetch	***Astragalus neglectus***	Flowering Plants	Pea Family	G4			US: IA, MI, MN, ND, NY, OH, PA, SD, VA,	Cliff Savanna	Riparian		
Crested Sedge	***Carex cristatella***	Flowering Plants	Sedge Family	G5			US: CT, DC (extirpated), DE, IA,				
Earleaf False Foxglove	***Agalinis auriculata***	Flowering Plants	Figwort Family	G3			US: AL, AR, DC, IA, IL, IN, KS, KY, MD,	Grassland/herbaceous			
Early Hairstreak	***Erora laeta***	Insects	Butterflies and Moths	GU			US: GA, KY, MA, MD, ME, MI, NC,	Forest - Hardwood Forest - Mixed			
Eastern Arogos Skipper	***Atrytone arogos arogos***	Insects	Butterflies and Moths	G3T1T2			US: AL, FL, GA, LA, MS, NC, NJ, NY, PA	Grassland/herbaceous Old field	Bog/fen HERBACEOUS WETLAND		
Eaton's Lipfern	***Cheilanthes eatonii***	Ferns and relatives		G5?			US: AR, AZ, CO, NM, OK, TX, UT, VA, WV				
Flat-stem Spikerush	***Eleocharis compressa***	Flowering Plants	Sedge Family	G4			US: AL, AR, CO, DC, GA, IA, IL, IN, KS,				
Fleshy Hawthorn	***Crataegus succulenta var. succulenta***	Flowering Plants	Rose Family	G4G5TNR			US: VA				
Four-flower Yellow Loosestrife	***Lysimachia quadriflora***	Flowering Plants	Primrose Family	G5?			US: AL, AR, DC, GA, IA, IL, IN, KY, MA,				
Fringed Gentian	***Gentianopsis crinita***	Flowering Plants	Gentian Family	G5			US: CT, DE (extirpated), GA, IA,				
Frosted Elfin	***Callophrys irus***	Insects	Butterflies and Moths	G3			US: AL, AR, CT, DC, DE, FL, GA, IL, IN,	Grassland/herbaceous Savanna			
Glade Spurge	***Euphorbia purpurea***	Flowering Plants	Spurge Family	G3			US: DE, GA, MD, NC, NJ, OH, PA, VA,				
Great Plains Ladies'-tresses	***Spiranthes magnicamporum***	Flowering Plants	Orchid Family	G4			US: AL, CO, GA, IA, IL, IN, KS, KY, LA,				
Green Floater	***Lasmigona subviridis***	Mollusks	Freshwater Mussels	G3		LC - Least concern	US: AL (extirpated), DC, GA (extirpated),				
Hellbender	***Cryptobranchus alleganiensis***	Amphibians	Salamanders	G3G4		NT - Near threatened	US: AL, AR, GA, IL, IN, KY, MD, MO,				
Herodias or Pine Barrens Underwing	***Catocala herodias gerhardi***	Insects	Butterflies and Moths	G3T3			US: CT, MA, NC, NJ, NY, VA, WV	Woodland - Conifer Woodland - Hardwood			
Herodias Underwing	***Catocala herodias***	Insects	Butterflies and Moths	G3			US: CT, MA, NC, NJ, NY, OK, TX, VA, WV	Savanna Woodland - Conifer			
Horned Beakrush	***Rhynchospora capillacea***	Flowering Plants	Sedge Family	G4			US: AL, AR, CT, IA, IL, IN, MA, ME, MI,				

Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species and their Habitats - Montgomery County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
Indiana Myotis	***Myotis sodalis***	Mammals	Bats	G2	LE: Listed endangered	EN - Endangered	US: AL, AR, CT, GA, IA, IL, IN, KY, MA,	Aerial Forest - Hardwood	Aerial FORESTED WETLAND		
Inland Sedge	***Carex interior***	Flowering Plants	Sedge Family	G5			US: AK, AR, AZ, CA, CO, CT, IA, ID, IL, IN,				
Jointed Rush	***Juncus articulatus***	Flowering Plants	Rush Family	G5			US: AK, AZ, CA, CO, CT, ID, IL, IN, KY,				
Juniper Sedge	***Carex juniperorum***	Flowering Plants	Sedge Family	G3			US: KY, OH, VA CA: ON				
Kanawha Minnow	***Phenacobius teretulus***	Fishes	Bony Fishes	G3G4		LC - Least concern	US: NC, VA, WV				
Large-bract Tick-trefoil	***Desmodium cuspidatum var. cuspidatum***	Flowering Plants	Pea Family	G5T5?			US: AL, AR, CT, DE, FL, GA, IA, IL, IN, KS,				
Largeleaf Grass-of-Parnassus	***Parnassia grandifolia***	Flowering Plants	Saxifrage Family	G3			US: AL, AR, FL, GA, KY, LA, MO, MS, NC,				
Laura's Clubtail	***Stylurus laurae***	Insects	Dragonflies and Damselflies	G4			US: AL, AR, FL, GA, IA, IN, KY, LA, MD,				
Loesel's Twayblade	***Liparis loeselii***	Flowering Plants	Orchid Family	G5			US: AL, AR, CT, DC (extirpated), IA, IL,				
Long Dash	***Polites mystic***	Insects	Butterflies and Moths	G5			US: AZ, CO, CT, IA, ID, IL, IN, MA, MD,	Grassland/herbaceous Old field	Bog/fen HERBACEOUS WETLAND		
Low Nutrush	***Scleria verticillata***	Flowering Plants	Sedge Family	G5			US: AR, CT, FL, GA, IA, IL, IN, LA, MD,				
Marbled Underwing	***Catocala marmorata***	Insects	Butterflies and Moths	G3G4		NE - Not evaluated	US: AR, CT, DE, GA, IL, IN, KY, LA, MO,	Forest - Hardwood	FORESTED WETLAND Riparian		
Matted Spikerush	***Eleocharis intermedia***	Flowering Plants	Sedge Family	G5			US: CT, IL, IN, MA, MD, ME, MI, MN,				
Montgomery County Cave Amphipod	***Stygobromus fergusoni***	Crustaceans	Amphipods	G2G3			US: VA				
Mottled Duskywing	***Erynnis martialis***	Insects	Butterflies and Moths	G3			US: AL, AR, CO, CT (extirpated), DC,	Grassland/herbaceous Shrubland/chaparral			
Northern Metalmark	***Calephelis borealis***	Insects	Butterflies and Moths	G3G4			US: AR, CT, IL, IN, KY, MD, MO, NJ,	Forest - Hardwood Woodland - Hardwood			
Northern Pygmy Clubtail	***Lanthus parvulus***	Insects	Dragonflies and Damselflies	G4			US: CT, KY, MA, MD, ME, NH, NY,				
Northern Spreadwing	***Lestes disjunctus***	Insects	Dragonflies and Damselflies	G5			US: AK, AZ, CA, CO, CT, ID, IL, IN, KS,				
Orangefin Madtom	***Noturus gilberti***	Fishes	Bony Fishes	G2		EN - Endangered	US: NC, VA				
Persius Duskywing	***Erynnis persius***	Insects	Butterflies and Moths	G5			US: AK, AZ, CA, CO, CT, ID, IL, IN, KS,	Alpine Grassland/herbaceous	Bog/fen Riparian		
Persius Duskywing	***Erynnis persius persius***	Insects	Butterflies and Moths	G5T1T3			US: CT, IN, MA, ME (extirpated), MI,	Savanna Woodland - Conifer	Bog/fen SCRUB-SHRUB WETLAND		
Pinnate-lobed Coneflower	***Rudbeckia triloba var. beadlei***	Flowering Plants	Aster Family	G5TNR			US: VA				
Piratebush	***Buckleya distichophylla***	Flowering Plants	Sandalwood Family	G3			US: NC, TN, VA	Bare rock/talus/scree Forest - Mixed			
Prairie Goldenrod	***Oligoneuron rigidum***	Flowering Plants	Aster Family	G5			US: AL, AR, CO, CT, DC (extirpated), DE,				
Prairie Rose	***Rosa setigera***	Flowering Plants	Rose Family	G5			US: AL, AR, CT, DC (extirpated), DE, FL,				
Prairies Bold Goldenrod	***Oligoneuron rigidum var. rigidum***	Flowering Plants	Aster Family	G5T5			US: AR, CT, DC, DE, IA, IL, IN, KS, KY, LA,				
Prostrate Blue Violet	***Viola walteri***	Flowering Plants	Violet Family	G4G5			US: AL, AR, FL, GA, KY, LA, MS, NC, OH,				
Quiet or Sweet Underwing	***Catocala dulciola***	Insects	Butterflies and Moths	G3			US: IL, IN, KY, MI, MO, NC, NY, OH,	Forest - Hardwood Woodland - Hardwood			
Regal Fritillary	***Speyeria idalia***	Insects	Butterflies and Moths	G3		NE - Not evaluated	US: AR, CO, CT (extirpated), DC	Grassland/herbaceous Old field	Bog/fen HERBACEOUS WETLAND		
Roanoke Logperch	***Percina rex***	Fishes	Bony Fishes	G1G2	LE: Listed endangered	VU - Vulnerable	US: NC, VA				
Schweinitz's Sedge	***Carex schweinitzii***	Flowering Plants	Sedge Family	G3G4			US: CT, MA, MI, MO, NY, PA, RI, VA,		Bog/fen FORESTED WETLAND		
Sedge Wren	***Cistothorus platensis***	Birds	Perching Birds	G5		LC - Least concern	US: AL, AR, CO, CT, CT, DC, DE, FL, GA,	Cropland/hedgerow Grassland/herbaceous	Bog/fen HERBACEOUS WETLAND		
Shining Ladies'-tresses	***Spiranthes lucida***	Flowering Plants	Orchid Family	G5			US: AL, AR, CT, DC (extirpated), DE, IA,				
Small Dropseed	***Sporobolus neglectus***	Flowering Plants	Grass Family	G5			US: AL, AR, AZ, CA, CO, CT, DC, IA, IL,				
Small White Lady's-slipper	***Cypripedium candidum***	Flowering Plants	Orchid Family	G4			US: AL, IA, IL, IN, KY, MD, MI, MN, MO,	Grassland/herbaceous	Bog/fen		
Small-head Rush	***Juncus brachycephalus***	Flowering Plants	Rush Family	G5			US: CO, CT, GA, IL, IN, LA, MA, MD,				

Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species and their Habitats - Montgomery County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
Smooth Purple Coneflower	***Echinacea laevigata***	Flowering Plants	Aster Family	G2G3	LE: Listed endangered		US: GA, NC, PA (extirpated), SC, VA	Bare rock/talus/scree Cliff			
Spatulate Snowfly	***Allocapnia simmonsi***	Insects	Stoneflies	G3			US: PA, VA, WV				
Spotted Joe-pyeweed	***Eupatorium maculatum***	Flowering Plants	Aster Family	G5			US: AL, AR, AZ, CO, CT, DC, GA, IA, ID,				
Spotted Joe-pyeweed	***Eupatorium maculatum var. maculatum***	Flowering Plants	Aster Family	G5T5			US: AL, AR, CT, DE, IL, IN, KY, MA, MD,				
Star Duckweed	***Lemna trisulca***	Flowering Plants	Other flowering plants	G5			US: AK, AL, AR, AZ, CA, CO, CT, DE, FL,				
Stiff Gentian	***Gentianella quinquefolia ssp. occidentalis***	Flowering Plants	Gentian Family	G5T4T5			US: AR, IA, IL, IN, KS, KY, LA, MI, MN,				
Stiff Gentian	***Gentianella quinquefolia***	Flowering Plants	Gentian Family	G5			US: AR, CT, GA, IA, IL, IN, KS, KY, LA,				
Sweet-scented Indian-plantain	***Hasteola suaveolens***	Flowering Plants	Aster Family	G4			US: CT, DC, IA, IL, IN, KY, MA, MD,				
Swordleaf Phlox	***Phlox buckleyi***	Flowering Plants	Phlox Family	G2			US: VA, WV	Barrens Forest Edge			
Tall Dropseed	***Sporobolus compositus var. compositus***	Flowering Plants	Grass Family	G5T5			US: AL, AR, AZ, CO, CT, DE, GA, IA, ID,				
Tall Dropseed	***Sporobolus compositus***	Flowering Plants	Grass Family	G5			US: AL, AR, AZ, CO, CT, DE, GA, IA, ID,				
Tennessee Bladderfern	***Cystopteris tennesseensis***	Ferns and relatives		G5			US: AL, AR, DE, GA, IA, IL, IN, KS, KY,				
Toothed Tick-trefoil	***Desmodium cuspidatum***	Flowering Plants	Pea Family	G5			US: AL, AR, CT, DC, DE, FL, GA, IA, IL,				
Torrey's Rush	***Juncus torreyi***	Flowering Plants	Rush Family	G5			US: AL, AR, AZ, CA, CO, DC (extirpated),				
Upright Greenbrier	***Smilax ecirrhata***	Flowering Plants	Greenbrier Family	G5?			US: AR, DC, GA, IA, IL, IN, KS, KY, MD,				
Vandel's Cave Isopod	***Caecidotea vandeli***	Crustaceans	Isopods	G3G4			US: MD, VA				
	Crataegus succulenta	Flowering Plants	Rose Family	G4G5			US: MN CA: ON				

Data as of January 2015

Report created September 29, 2015

Name search criteria not specified

Location: US County 51121 (Montgomery County)

Conservation Status search criteria not specified

Citation: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

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Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species of Conservation Concern - Montgomery County

Scientific Name[2]	Common Name	Major Group	NatureServe Global Status	U.S. Federal Status[3]	State Status
Addison's Leatherflower	Flowering Plants	G1: Critically Imperiled		S1?	
Smooth Purple Coneflower	Flowering Plants	G2: Imperiled	LE	S2	
A Dipluran	Diplurans, Springtails, and Proturans	G2: Imperiled		S2	
Orangefin Madtom	Freshwater and Anadromous Fishes	G2: Imperiled		S2	
Canby's Mountain-lover	Flowering Plants	G2: Imperiled		S2	
Roanoke Logperch	Freshwater and Anadromous Fishes	G1: Critically Imperiled	LE	S1S2	
Swordleaf Phlox	Flowering Plants	G2: Imperiled		S2	
A Ground Beetle	Other Beetles	G2: Imperiled		S1S2	
A Millipede	Millipedes and Centipedes	G2: Imperiled		S1	
Appalachian Grizzled Skipper	Butterflies and Skippers	G1: Critically Imperiled		S1	

[1] U.S. ESA Listed, Proposed, Candidate and NatureServe Imperiled (G1-G2) Species

Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species and their Habitats - Pulaski County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
A Cave Beetle	***Pseudanophthalmus sp. 7***	Insects	Beetles	G1			US: VA				
A Dipluran	***Litocampa sp. 3***	Diplurans, Springtails and		G2			US: VA				
Black-tipped Darner	***Aeshna tuberculifera***	Insects	Dragonflies and Damselflies	G4			US: CT, DE, IA, IN, MA, MD, ME, MI,				
Bradley's Spleenwort	***Asplenium bradleyi***	Ferns and relatives		G4			US: AL, AR, GA, IL, IN, KY, LA, MD, MO,	Bare rock/talus/scree Cliff			
Canby's Mountain-lover	***Paxistima canbyi***	Flowering Plants	Bittersweet Family	G2			US: KY, MD, NC, OH, PA, TN, VA, WV	Barrens Cliff			
Candy Darter	***Etheostoma osburni***	Fishes	Bony Fishes	G3		NT - Near threatened	US: VA, WV				
Creeping Aster	***Eurybia surculosa***	Flowering Plants	Aster Family	G4G5			US: AL, GA, KY, NC, OH, SC, TN, VA				
Eaton's Lipfern	***Cheilanthes eatonii***	Ferns and relatives		G5?			US: AR, AZ, CO, NM, OK, TX, UT, VA, WV				
Fee's Lipfern	***Cheilanthes feei***	Ferns and relatives		G5			US: AR, AZ, CA, CO, IA, ID, IL, KS, KY,				
Green Floater	***Lasmigona subviridis***	Mollusks	Freshwater Mussels	G3		LC - Least concern	US: AL (extirpated), DC, GA (extirpated),				
Hellbender	***Cryptobranchus alleganiensis***	Amphibians	Salamanders	G3G4		NT - Near threatened	US: AL, AR, GA, IL, IN, KY, MD, MO,				
Henrot's Cave Isopod	***Caecidotea henroti***	Crustaceans	Isopods	G2			US: VA				
Henslow's Sparrow	***Ammodramus henslowii***	Birds	Perching Birds	G4		NT - Near threatened	US: AL, AR, CT, DC, DE, DE, FL, GA, IA,	Grassland/herbaceous			
James Cave Amphipod	***Stygobromus abditus***	Crustaceans	Amphipods	G2G3			US: VA				
Kanawha Minnow	***Phenacobius teretulus***	Fishes	Bony Fishes	G3G4		LC - Least concern	US: NC, VA, WV				
Mitchell's Satyr Butterly	***Neonumpha mitchelli mitchelli***	Insects	Butterflies and Moths	G2T2	LE: Listed endangered	NE - Not evaluated	US: IN, MI, NJ, OH, VA		Bog/fen HERBACEOUS WETLAND		
Piratebush	***Buckleya distichophylla***	Flowering Plants	Sandalwood Family	G3			US: NC, TN, VA	Bare rock/talus/scree Forest - Mixed			
Plains Muhlenbergia	***Muhlenbergia cuspidata***	Flowering Plants	Grass Family	G5			US: AR, CO, IA, IL, IN, KS, KY, MI				
Prairie Goldenrod	***Oligoneuron rigidum***	Flowering Plants	Aster Family	G5			US: AL, AR, CO, CT, DC (extirpated), DE,				
Prairies Bold Goldenrod	***Oligoneuron rigidum var. rigidum***	Flowering Plants	Aster Family	G5T5			US: AR, CT, DC, DE, IA, IL, IN, KS, KY, LA,				
Prostrate Blue Violet	***Viola walteri***	Flowering Plants	Violet Family	G4G5			US: AL, AR, FL, GA, KY, LA, MS, NC, OH,				
Purple Fringeless Orchid	***Platanthera peramoena***	Flowering Plants	Orchid Family	G5			US: AL, AR, DC (extirpated), DE, GA,				
Regal Fritillary	***Speyeria idalia***	Insects	Butterflies and Moths	G3		NE - Not evaluated	US: AR, CO, CT (extirpated), DC	Grassland/herbaceous Old field	Bog/fen HERBACEOUS WETLAND		
Schweinitz's Sedge	***Carex schweinitzii***	Flowering Plants	Sedge Family	G3G4			US: CT, MA, MI, MO, NY, PA, RI, VA,		Bog/fen FORESTED WETLAND		
Small-head Rush	***Juncus brachycephalus***	Flowering Plants	Rush Family	G5			US: CO, CT, GA, IL, IN, LA, MA, MD, ME,				
Smooth Purple Coneflower	***Echinacea laevigata***	Flowering Plants	Aster Family	G2G3	LE: Listed endangered		US: GA, NC, PA (extirpated), SC, VA	Bare rock/talus/scree Cliff			
Sweet-scented Indian-plantain	***Hasteola suaveolens***	Flowering Plants	Aster Family	G4			US: CT, DC, IA, IL, IN, KY, MA, MD, MN,				
Swordleaf Phlox	***Phlox buckleyi***	Flowering Plants	Phlox Family	G2			US: VA, WV	Barrens Forest Edge			
Tennessee Bladderfern	***Cystopteris tennesseensis***	Ferns and relatives		G5			US: AL, AR, DE, GA, IA, IL, IN, KS, KY,				
Virginia Coil	***Polygyriscus virginianus***	Mollusks	Terrestrial Snails	G1	LE: Listed endangered	DD - Data deficient	US: VA	Bare rock/talus/scree Shrubland/chaparral			

Data as of January 2015

Report created September 29, 2015

Name search criteria not specified

Location: US County 51155 (Pulaski)

Conservation Status search criteria not specified

Citation: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

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Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species of Conservation Concern - Pulaski County

Scientific Name[2]	Common Name	Major Group	NatureServe Global Status	U.S. Federal Status[3]	State Status
Henrot's Cave Isopod	Isopods	G2: Imperiled		S2	
Smooth Purple Coneflower	Flowering Plants	G2: Imperiled	LE	S2	
A Dipluran	Diplurans, Springtails, and Proturans	G2: Imperiled		S2	
Canby's Mountain-lover	Flowering Plants	G2: Imperiled		S2	
Swordleaf Phlox	Flowering Plants	G2: Imperiled		S2	
Virginia Coil	Terrestrial Snails	G1: Critically Imperiled	LE	S1	
A Cave Beetle	Other Beetles	G1: Critically Imperiled		S1	
James Cave Amphipod	Amphipods	G2: Imperiled		S2S3	

[1] U.S. ESA Listed, Proposed, Candidate and NatureServe Imperiled (G1-G2) Species

Source: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Species and their Habitats - Giles County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
A Beetle	***Atheta annexa***	Insects	Beetles	G4			US: AL, IN, VA				
A Cave Beetle	***Pseudanophthalmus gracilis***	Insects	Beetles	G1G2			US: VA				
A Cave Dipluran (Salamander Cave)	***Litocampa sp. 1***	Diplurans, Springtails and		G1			US: AL, VA, WV				
A Cave Springtail	***Pygmarrhopalites commorus***	Diplurans, Springtails and		G2G3			US: VA, WV				
A Geometrid Moth	***Euchlaena milnei***	Insects	Butterflies and Moths	G2G4			US: IL, NC, OH, VA, WI, WV	Forest - Hardwood			
A Millipede	***Rudiloria trimaculata***	Millipedes and Centipedes		G5			US: VA CA: ON				
A Millipede	***Rudiloria trimaculata tortua***	Millipedes and Centipedes		G5T2			US: VA				
A Millipede	***Pseudotremia sublevis***	Millipedes and Centipedes		G2G3			US: VA				
A Noctuid Moth	***Anaplectoides brunneomedia***	Insects	Butterflies and Moths	G4			US: VA, WV				
Alabama Lipfern	***Cheilanthes alabamensis***	Ferns and relatives		G4G5			US: AL, AR, AZ, FL, GA, KS, KY, LA				
Allegheny Snaketail	***Ophiogomphus incurvatus alleghaniensis***	Insects	Dragonflies and Damselflies	G3T2T3		VU - Vulnerable	US: AL, TN, VA, WV				
American Harebell	***Campanula rotundifolia***	Flowering Plants	Other flowering plants	G5			US: AK, AZ, CA, CO, CT, IA, ID, IL, IN,				
Appalachian Bewick's Wren	***Thryomanes bewickii altus***	Birds	Perching Birds	G5T2Q			US: AL, GA, MD (extirpated), NC				
Appalachian Snaketail	***Ophiogomphus incurvatus***	Insects	Dragonflies and Damselflies	G3		NT - Near threatened	US: AL, GA, MD, NC, PA, SC, TN, VA, WV				
Bentley's Coralroot	***Corallorhiza bentleyi***	Flowering Plants	Orchid Family	G2			US: VA, WV				
Bewick's Wren	***Thryomanes bewickii***	Birds	Perching Birds	G5		LC - Least concern	US: AL, AL, AR, AZ, CA, CO, DC, GA, IA,	Old field Shrubland/chaparral	Riparian		
Big Sandy Crayfish	***Cambarus veteranus***	Crustaceans	Crayfishes	G2		DD - Data deficient	US: KY, VA, WV				
Black Dash	***Euphyes conspicua***	Insects	Butterflies and Moths	G4			US: CT, DE, IA, IL, IN, MA, MD, MI, MN,		Bog/fen FORESTED WETLAND		
Black-tipped Darner	***Aeshna tuberculifera***	Insects	Dragonflies and Damselflies	G4			US: CT, DE, IA, IN, MA, MD, ME, MI,				
Blue Ridge Bittercress	***Cardamine flagellifera***	Flowering Plants	Mustard Family	G3			US: GA, NC, SC, TN, VA, WV				
Blunt-lobe Grapefern	***Botrychium oneidense***	Ferns and relatives		G4			US: CT, DC (extirpated), DE, IL,				
Bog Bluegrass	***Poa paludigena***	Flowering Plants	Grass Family	G3			US: DE, IA, IL (extirpated), IN, MI,				
Bog Clubmoss	***Lycopodiella inundata***	Ferns and relatives		G5			US: AK, CA, CT, IA, ID, IL, IN, KY, MA,				
Bog Fern	***Thelypteris simulata***	Ferns and relatives		G4G5			US: AL, CT, DC, DE, MA, MD, ME, NC,				
Brown Peatmoss	***Sphagnum fuscum***	Mosses		G5			US: IN, MI, MT, NC, NJ, VA, VT, WI, WY				
Brown-eyed-Susan	***Rudbeckia triloba***	Flowering Plants	Aster Family	G5			US: AL, AR, CO, CT, DC, DE, FL, GA, IA,				
Buxbaum's Sedge	***Carex buxbaumii***	Flowering Plants	Sedge Family	G5			US: AK, AR, CA, CO, CT, DC, DE, GA, IA,	Bare rock/talus/scree Forest - Hardwood	Bog/fen FORESTED WETLAND		
Canby's Mountain-lover	***Paxistima canbyi***	Flowering Plants	Bittersweet Family	G2			US: KY, MD, NC, OH, PA, TN, VA, WV	Barrens Cliff			
Candy Darter	***Etheostoma osburni***	Fishes	Bony Fishes	G3		NT - Near threatened	US: VA, WV				
Celandine Poppy	***Stylophorum diphyllum***	Flowering Plants	Poppy Family	G5			US: AL, AR, DC, DE, GA, IL, IN, KY, MD,				
Dwarf Rattlesnake-plantain	***Goodyera repens***	Flowering Plants	Orchid Family	G5			US: AK, AZ, CO, CT, ID, KY, MA, MD, ME,				
Early Hairstreak	***Erora laeta***	Insects	Butterflies and Moths	GU			US: GA, KY, MA, MD, ME, MI, NC,	Forest - Hardwood Forest - Mixed			
Eastern Small-footed Myotis	***Myotis leibii***	Mammals	Bats	G3G4		LC - Least concern	US: AR, CT, GA, KY, MA, MD, MD, ME,	Bare rock/talus/scree Cliff	Aerial Riparian		
Eaton's Lipfern	***Cheilanthes eatonii***	Ferns and relatives		G5?			US: AR, AZ, CO, NM, OK, TX, UT, VA, WV				
Ephemeral Cave Amphipod	***Stygobromus ephemerus***	Crustaceans	Amphipods	G1G2		VU - Vulnerable	US: VA				
Five-ranked Bogmoss	***Sphagnum quinquefarium***	Mosses		G5			US: GA, KY, MI, NJ, TN, VA, VT				

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Species and their Habitats - Giles County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
Flexuous Peatmoss	***Sphagnum flexuosum***	Mosses		G5			US: MA, NC, NJ, PA, VA, VT				
Fowl Bluegrass	***Poa palustris***	Flowering Plants	Grass Family	G5			US: AK, AZ, CA, CO, CT, DC, DE, IA, ID, IL,				
Fresh Water Cordgrass	***Spartina pectinata***	Flowering Plants	Grass Family	G5			US: AR, CO, CT, DC, DE, GA, IA, ID, IL, IN,				
Girgensohn's Peatmoss	***Sphagnum girgensohnii***	Mosses		G5			US: CO, IN, MI, MT, TN, VA, VT, WI				
Green Comma	***Polygonia faunus***	Insects	Butterflies and Moths	G5			US: AK, AZ, CA, CO, GA, ID, KY, MA, ME,	Forest - Conifer Forest - Mixed	Riparian		
Green Floater	***Lasmigona subviridis***	Mollusks	Freshwater Mussels	G3		LC - Least concern	US: AL (extirpated), DC, GA (extirpated),				
Hairy Willowherb	***Epilobium ciliatum***	Flowering Plants	Evening-Primrose Family	G5			US: AK, AZ, CA, CO, CT, DE, HI, IA, ID, IL,				
Hairy Willowherb	***Epilobium ciliatum ssp. ciliatum***	Flowering Plants	Evening-Primrose Family	G5T5			US: AK, AZ, CA, CO, CT, DE, IA, ID, IL, IN,				
Hellbender	***Cryptobranchus alleganiensis***	Amphibians	Salamanders	G3G4		NT - Near threatened	US: AL, AR, GA, IL, IN, KY, MD, MO,				
Henrot's Cave Isopod	***Caecidotea henroti***	Crustaceans	Isopods	G2			US: VA				
Indiana Myotis	***Myotis sodalis***	Mammals	Bats	G2	LE: Listed endangered	EN - Endangered	US: AL, AR, CT, GA, IA, IL, IN, KY, MA,	Aerial Forest - Hardwood	Aerial FORESTED WETLAND		
James Cave Amphipod	***Stygobromus abditus***	Crustaceans	Amphipods	G2G3			US: VA				
James Spinymussel	***Pleurobema collina***	Mollusks	Freshwater Mussels	G1	LE: Listed endangered	CR - Critically endangered	US: NC, VA, WV				
Jefferson's Short-nosed Scorpionfly	***Brachypanorpa jeffersoni***	Insects	Other Insects	G2			US: VA				
Lanceleaf Grapefern	***Botrychium lanceolatum var. angustisegmentum***	Ferns and relatives		G5T4			US: CT, MA, MD, ME, MI, MN, NC,				
Large Cranberry	***Vaccinium macrocarpon***	Flowering Plants	Heath Family	G4			US: CA, CT, DE, IL, IN, MA, MD, ME,				
Large Purple-fringe Orchis	***Platanthera grandiflora***	Flowering Plants	Orchid Family	G5			US: CT, DC, DE (extirpated), GA,				
Large-bract Tick-trefoil	***Desmodium cuspidatum var. cuspidatum***	Flowering Plants	Pea Family	G5T5?			US: AL, AR, CT, DE, FL, GA, IA, IL, IN, KS,				
Largeleaf Grass-of-Parnassus	***Parnassia grandifolia***	Flowering Plants	Saxifrage Family	G3			US: AL, AR, FL, GA, KY, LA, MO, MS, NC,				
Leathery Grapefern	***Botrychium multifidum***	Ferns and relatives		G5			US: AK, AZ, CA, CO, CT, IA, ID, IL, IN,				
Loesel's Twayblade	***Liparis loeselii***	Flowering Plants	Orchid Family	G5			US: AL, AR, CT, DC (extirpated), IA, IL,				
Loggerhead Shrike	***Lanius ludovicianus***	Birds	Perching Birds	G4		LC - Least concern	US: AL, AR, AZ, CA, CO, CO, CT	Cropland/hedgerow Desert			
Longleaf Bluets	***Houstonia canadensis***	Flowering Plants	Madder Family	G4G5			US: GA, IL, IN, KY, ME, MI, MN, MO,				
Long-stalk Holly	***Ilex collina***	Flowering Plants	Holly Family	G3			US: GA, NC, TN, VA, WV	Forest - Conifer Forest - Mixed	FORESTED WETLAND Riparian		
Marsh St. John's-wort	***Triadenum fraseri***	Flowering Plants	St. John's-Wort Family	G5			US: CT, DE, IA, IL, IN, MA, ME, MI, MN,				
Nannyberry	***Viburnum lentago***	Flowering Plants	Honeysuckle Family	G5			US: CO, CT, DC, DE, GA, IA, IL, IN, MA,				
Narrow-panicle Rush	***Juncus brevicaudatus***	Flowering Plants	Rush Family	G5			US: AZ, CO, CT, ID, MA, MD, ME, MI,				
New River Valley Cave Beetle	***Pseudanophthalmus egberti***	Insects	Beetles	G1G2			US: VA				
Northern Metalmark	***Calephelis borealis***	Insects	Butterflies and Moths	G3G4			US: AR, CT, IL, IN, KY, MD, MO, NJ, NY,	Forest - Hardwood Woodland - Hardwood			
Northern Pitcherplant	***Sarracenia purpurea***	Flowering Plants	Pitcherplant Family	G5			US: AL, CA, CT, DC, DE, FL, GA, IL, IN,				
Olympia Marble	***Euchloe olympia***	Insects	Butterflies and Moths	G4G5			US: AR, CO, IA, IL, IN, KS, KY, MD, MI,	Grassland/herbaceous Sand/dune			
Peters Mountain Mallow	***Iliamna corei***	Flowering Plants	Mallow Family	G1	LE: Listed endangered		US: VA	Forest - Mixed Forest/Woodland			
Pinnate-lobed Coneflower	***Rudbeckia triloba var. beadlei***	Flowering Plants	Aster Family	G5TNR			US: VA				
Piratebush	***Buckleya distichophylla***	Flowering Plants	Sandalwood Family	G3			US: NC, TN, VA	Bare rock/talus/scree Forest - Mixed			
Plains Muhlenbergia	***Muhlenbergia cuspidata***	Flowering Plants	Grass Family	G5			US: AR, CO, IA, IL, IN, KS, KY, MI				
Prostrate Blue Violet	***Viola walteri***	Flowering Plants	Violet Family	G4G5			US: AL, AR, FL, GA, KY, LA, MS, NC, OH,				
Purple Fringeless Orchid	***Platanthera peramoena***	Flowering Plants	Orchid Family	G5			US: AL, AR, DC (extirpated), DE, GA,				

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Species and their Habitats - Giles County

Name		Taxonomy		Conservation Status			Distribution	Habitats			
Common Name	Scientific Name	Species Group (Broad)	Species Group (Fine)	NatureServe Global Status	U.S. Endangered Species Act Status	IUCN Red List Status	Country: States/ Provinces	Terrestrial Habitat(s)	Palustrine Habitat(s)	Riverene Habitat(s)	Estuarine Habitat(s)
Red Peatmoss	***Sphagnum rubellum***	Mosses		G5			US: MI, NC, VA, VT, WI				
Regal Fritillary	***Speyeria idalia***	Insects	Butterflies and Moths	G3		NE - Not evaluated	US: AR, CO, CT (extirpated), DC	Grassland/herbaceous Old field	Bog/fen HERBACEOUS WETLAND		
River Bulrush	***Schoenoplectus fluviatilis***	Flowering Plants	Sedge Family	G5			US: AZ, CA, CO, CT, DC, DE, IA, ID, IL, IN,				
Rough Wood-aster	***Eurybia radula***	Flowering Plants	Aster Family	G5			US: CT, DE, KY, MA, MD, ME, NH, NJ, NY,				
Satin-curls	***Clematis catesbyana***	Flowering Plants	Buttercup Family	G4G5			US: AL, AR, FL, GA, KS, KY, LA, MO, MS,				
Shinleaf	***Pyrola elliptica***	Flowering Plants	Other flowering plants	G5			US: AZ, CT, DC, DE, IA, ID, IL, IN, MA,				
Showy Lady's-slipper	***Cypripedium reginae***	Flowering Plants	Orchid Family	G4			US: AL, AR, CT, IA, IL, IN, KY				
Silver-bordered Fritillary	***Boloria selene***	Insects	Butterflies and Moths	G5			US: CO, CT, DC, DE, IA, ID, IL, IN, MA,	Grassland/herbaceous	Bog/fen HERBACEOUS WETLAND		
Ski-tipped Emerald	***Somatochlora elongata***	Insects	Dragonflies and Damselflies	G5			US: CT, GA, MA, MD, ME, MI, MN,				
Small-head Rush	***Juncus brachycephalus***	Flowering Plants	Rush Family	G5			US: CO, CT, GA, IL, IN, LA, MA, MD, ME,				
Smooth Azalea	***Rhododendron arborescens***	Flowering Plants	Heath Family	G4G5			US: AL, GA, KY, MD, MS, NC, NY, PA, SC,				
Smyth's Green Comma	***Polygonia faunus smythi***	Insects	Butterflies and Moths	G5T3			US: GA, KY, NC, SC, TN, VA, WV	Forest - Conifer Forest - Mixed			
Snowy Campion	***Silene nivea***	Flowering Plants	Pink Family	G4?			US: DC (extirpated), GA, IA, IL, IN, MD,				
Sphagnum	***Sphagnum subtile***	Mosses		G5?Q			US: MO, NC, NJ, VA, VT				
Spotted Cave Beetle	***Pseudanophthalmus punctatus***	Insects	Beetles	G2G3			US: VA				
Spring Blue-eyed Mary	***Collinsia verna***	Flowering Plants	Figwort Family	G5			US: AL, AR, IA, IL, IN, KS, KY, LA, MI, MO,				
Straley's Cave Beetle	***Pseudanophthalmus quadratus***	Insects	Beetles	G1			US: VA				
Stygian Shadowdragon	***Neurocordulia yamaskanensis***	Insects	Dragonflies and Damselflies	G5			US: AL, AR, CT, IA, IL, IN, KY, MA, MD,				
Tawny Crescent	***Phyciodes batesii batesii***	Insects	Butterflies and Moths	G4T1			US: KY, MD, ME (extirpated), MI,	Grassland/herbaceous Old field			
Tawny Crescent	***Phyciodes batesii***	Insects	Butterflies and Moths	G4			US: AZ, GA, KY, MD, ME (extirpated), MI,	Grassland/herbaceous Old field			
Tennessee Pondweed	***Potamogeton tennesseensis***	Flowering Plants	Pondweed Family	G2G3			US: NC, OH, PA, TN, VA, WV				
Toothed Tick-trefoil	***Desmodium cuspidatum***	Flowering Plants	Pea Family	G5			US: AL, AR, CT, DC, DE, FL, GA, IA, IL, IN,				
Torrey's Mountainmint	***Pycnanthemum torrei***	Flowering Plants	Mint Family	G2			US: CT, DC (extirpated), DE, IL,	Forest - Hardwood Forest/Woodland			
Triangle Grapefern	***Botrychium lanceolatum***	Ferns and relatives		G5			US: AK, AZ, CA, CO, CT, ID, KY, MA, MD,				
Tuberous Grass-pink	***Calopogon tuberosus***	Flowering Plants	Orchid Family	G5			US: AL, AR, CT, DC (extirpated), DE, FL,				
Vandel's Cave Isopod	***Caecidotea vandeli***	Crustaceans	Isopods	G3G4			US: MD, VA				
White-faced Meadowhawk	***Sympetrum obtrusum***	Insects	Dragonflies and Damselflies	G5			US: CA, CO, CT, IA, ID, IL, IN, KS, KY,				
Wild Hyacinth	***Camassia scilloides***	Flowering Plants	Lily Family	G4G5			US: AL, AR, DC, GA, IA, IL, IN, KS, KY, LA,				
Yellow Pitcherplant	***Sarracenia flava***	Flowering Plants	Pitcherplant Family	G5?			US: AL, FL, GA, NC, NJ, SC, VA				
Yellow Sedge	***Carex flava***	Flowering Plants	Sedge Family	G5			US: AK, CT, ID, IN, MA, ME, MI, MN,				

Data as of January 2015
Report created September 29, 2015
Name search criteria not specified
Location: US County 51071 (Giles)
Conservation Status search criteria not specified
Citation: 2015 NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

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Species of Conservation Concern - Giles County

Scientific Name[2]	Common Name	Major Group	NatureServe Global Status	U.S. Federal Status[3]	State Status
Jefferson's Short-nosed Scorpionfly	Other Insects	G2: Imperiled		S1S2	
Henrot's Cave Isopod	Isopods	G2: Imperiled		S2	
Big Sandy Crayfish	Crayfishes	G2: Imperiled		S1S2	
Bentley's Coralroot	Flowering Plants	G2: Imperiled		S1	
Peters Mountain Mallow	Flowering Plants	G1: Critically Imperiled	LE	S1	
A Cave Dipluran (Salamander Cave)	Diplurans, Springtails, and Proturans	G1: Critically Imperiled		S1	
Canby's Mountain-lover	Flowering Plants	G2: Imperiled		S2	
James Spinymussel	Freshwater Mussels	G1: Critically Imperiled	LE	S1	
Spotted Cave Beetle	Other Beetles	G2: Imperiled		S1	
Straley's Cave Beetle	Other Beetles	G1: Critically Imperiled		S1	
A Millipede	Millipedes and Centipedes	G2: Imperiled		S2S3	
Torrey's Mountainmint	Flowering Plants	G2: Imperiled		S2?	
A Cave Springtail	Diplurans, Springtails, and Proturans	G2: Imperiled		S2S3	
James Cave Amphipod	Amphipods	G2: Imperiled		S2S3	
Ephemeral Cave Amphipod	Amphipods	G1: Critically Imperiled		S1	

[1] U.S. ESA Listed, Proposed, Candidate and NatureServe Imperiled (G1-G2) Species

ANIMAL SURVEYS AT THE RADFORD ARMY AMMUNITION PLANT, 2012-2013

Report prepared for
Radford Army Ammunition Plant
Radford, Virginia
Attn: Len DiIoia, Biologist

4 September 2013

By

Karen E. Powers
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Radford, Virginia 24142

Introduction

The Radford Army Ammunition Plant (RFAAP) contracted Radford University to perform multiple biological surveys on both the Main Plant and the New River Unit in summer 2013. The last large-scale biological survey of the properties was completed ca. 1998 (VDGIF 1999), and included sampling for rare mammals, birds, vegetation, insects, and more. A smaller-scale predator survey also was implemented in 2003 by Conservation Management Institute (Convery and Klopfer 2003). Several small-scale surveys for northern bobwhite (*Colinus virginianus*), other birds, and bats also were completed by Radford University in 2012.

Radford University was contracted to complete a subset of these surveys, which included those for frogs, salamanders, small mammals, birds, and butterflies, and we present our results in this report. We also present current results from a camera-trapping project that began in August 2012 and is on-going.

Surveys by Taxon

Small mammals

Methods—We surveyed six sites on the New River Unit from 28-31 May, 2013 and six sites on the Main Plant from 25-28 June 2013 (Appendix 1, Figure 1), using a combination of snap traps (45), Sherman live traps (45), and pitfalls (45). Due to the substrate of the habitats, pitfalls were used sparingly or not at all at a few sites on the Main Plant, and trap effort varied nominally among sites (Table 1).

Figure 1. Examples of sites surveyed at New River Unit and Main Plant of Radford Army Ammunition Plant, summer 2013.

Table 1. Trapping effort for 12 sites surveys for small mammals in May and June, 2013. Trap-nights are calculated as the total number of traps × the number of nights surveyed (3).

Tract	**Site**	No. Shermans	No. Snap Traps	No. Pitfalls	Trap-nights
MAIN	Frog Marsh	45	45	45	405
MAIN	Hardwood roadside	45	45	45	405
MAIN	Open grassland	45	45	45	405
MAIN	Stream	45	45	16	318
MAIN	Walls	45	45	10	300
MAIN	Train Tracks	45	45	0	270
NRU	Burn Field	45	45	45	405
NRU	Grassland	45	45	45	405
NRU	Ephemeral Stream	45	45	45	405
NRU	Fishing Pond	45	45	45	405
NRU	Pond2 & Food Plot	45	45	45	405
NRU	Pwamp	45	45	45	405
	Total				

Results—In 4533 trap-nights, we captured 150 individuals of eight species (Table 2). These species included 2 insectivore species (*Blarina brevicauda* [northern short-tailed shrew], *Sorex hoyi* [pygmy shrew]*), 5 rodent species (*Peromyscus leucopus* [white-footed mouse], *P. maniculatus* [deer mouse*], *Microtus pennsylvanicus* [meadow vole], *Zapus hudsonius* [meadow jumping mouse], and *Tamias striatus* [eastern chipmunk]), and one lagomorph (*Sylvilagus floridanus* [eastern cottontail]; Figure 2). Asterisks indicate this species was not documented in 1999 report. Overall trap success was 3.3%.

Figure 2. Examples of species captured in small mammal surveys in May and June, 2013: A) Eastern cottontail, B) Meadow jumping mouse, C) White-footed mouse, D) Pygmy shrew, and E) Meadow vole

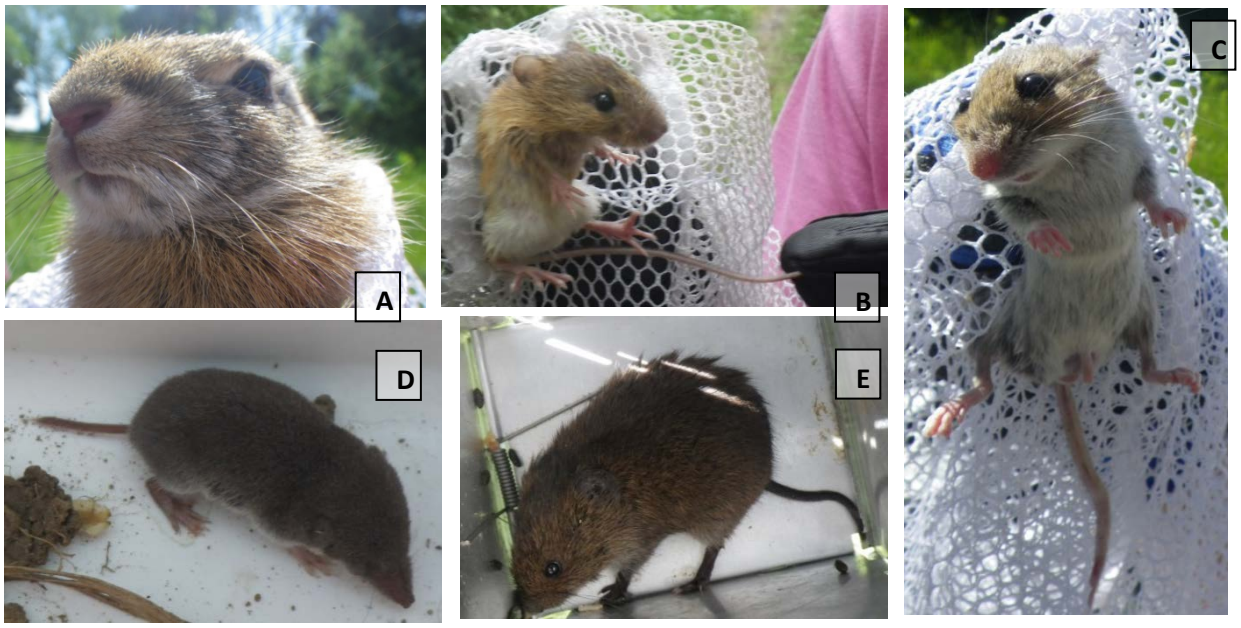

Table 2. Capture results by species for small mammal surveys completed in May and June, 2013 at both tracts (MAIN: Main Plant; NRU: New River Unit) of the Radford Army Ammunition Plant. Presented is number of individuals captured per site. Species with an (*) were not documented in 1999 report. See Appendix 1 for GPS coordinates.

Site	***Blarina brevicauda***	***Microtus pennsylvanicus***	***Peromyscus leucopus***	***Peromyscus maniculatus****	***Peromyscus* sp.**	***Sorex hoyi****	***Sylvilagus floridanus***	***Tamias striatus***	***Zapus hudsonius***	**Total**
MAIN- Frog Marsh	1	1	1							**3**
MAIN- Hardwood Roadside			4	1		1				**6**
MAIN- Open Grassland		2								**2**
MAIN- Stream			7	4				1	2	**14**
MAIN- Walls			3	5						**8**
MAIN- Train Tracks										**0**
NRU- Burn Field		3	3			3				**9**
NRU- Grassland		6	7	5						**18**
NRU- Ephemeral Stream	6		17	8	3					**34**
NRU- Fishing Pond	14	10	7	6			1			**38**
NRU- Pond & Food Plot	4	9	2	1						**16**
NRU- Pwamp			1	1						**2**
Grand Total	**25**	**31**	**52**	**31**	**3**	**4**	**1**	**1**	**2**	**150**

Frogs

Methods—Following the protocol of the Virginia Frog and Toad Calling Survey (http://www.dgif.virginia.gov/ WILDLIFE/ frogsurvey/vftsprotocols.pdf), we completed surveys for frogs on the New River Unit (10 sites, April 9 & May 21) and the Main Plant (5 sites, April 18 & May 23; Appendix 1). At each stop, we listened for calls for five minutes. Species calls were rated on a 0-3 scale: 0 = species was not heard, 1 = few distinct individuals heard; 2 = multiple individuals heard but calls among individuals could be distinguished; and 3 = full chorus present, and individual calls could not be differentiated.

Results—We documented seven species of frogs and toads in our two rounds of surveys (Table 3). Spring peepers (*Pseudacris crucifer*) were nearly ubiquitous, while American toads (*Anaxyrus americanus*), green frogs (*Lithobates clamitans*), and grey treefrogs (*Hyla versicolor*) also were well represented. We documented no rare species or state species of concern. However, bullfrogs (*L. catesbeianus*), green frogs, southern leopard frogs (*Lithobates sphenocephala*), and pickerel frogs (*L. palustris*) were not documented in VDGIF's 1999 survey.

Table 3. Detection results for frog and toad calling surveys in April & May, 2013 on both tracts (MAIN: Main Plant; NRU: New River Unit) of the Radford Army Ammunition Plant. Call ratings described in-text. Parentheses indicate call was heard outside of the designated habitat surveyed. Species with an (*) were not documented in 1999 report. See Appendix 1 for GPS coordinates.

Location	**Site Name**	**Date**	*Anaxyrus americanus*	*Lithobates catesbeianus**	*Lithobates clamitans**	*Lithobates palustris**	*Lithobates sphenocephala**	*Hyla versicolor*	*Pseudacris crucifer*
NRU	Sinkhole	4/9/13	1						3
		5/21/13							1
NRU	Pwamp	4/9/13							3
		5/21/13						1	1
NRU	Fen	4/9/13	(1)						(3)
		5/21/13						(1)	(1)
NRU	Pond2	4/9/13	2				1		3
		5/21/13		1	1			1	3
NRU	Roadside ditch	4/9/13	1				2		3
		5/21/13		(1)					2
NRU	Food plot drainage	4/9/13					2		2
		5/21/13							
NRU	Fishing pond	4/9/13	2				1		3
		5/21/13			2				1
NRU	Creek by 52	4/9/13					1		2
		5/21/13							(1)
NRU	Sneezeweed	4/9/13							
		5/21/13							1

Location	Site Name	Date	*Anaxyrus americanus*	*Lithobates catesbeianus**	*Lithobates clamitans**	*Lithobates palustris**	*Lithobates sphenocephala**	*Hyla versicolor*	*Pseudacris crucifer*
NRU	Firewater	4/9/13	1				2		(3)
		5/21/13			1				(3)
MAIN	TNT Swamp	4/18/13							3
		5/23/13			1				
MAIN	Peeper Marsh	4/18/13	1						3
		5/23/13						(2)	(2)
MAIN	The Walls	4/18/13	1					2	3
		5/23/13			1			3	2
MAIN	Ghost's Haunt	4/18/13							3
		5/23/13			1			2	2
MAIN	Pier Pond	4/18/13	1			1			(2)
		5/23/13			1			1	1

Salamanders

Methods—On 16 May 2013, a team of four students and researchers searched for salamanders on both property parcels. Survey sites included ponds, streams, swamp borders, and other areas high in soil moisture. Search efforts in and out of the water included turning over logs and rocks and sifting through leaf litter. Exact locations were not documented via GPS.

Results—We discovered seven plethodontid salamander species (Table 4, Figure 3). None are considered species of concern or species at risk in the Commonwealth. However, northern red salamanders (*Pseudotriton ruber*), grey-cheeked salamanders (*Desmognathus montanus*), Alleghany Mountain dusky salamander (*D. ochrophaeus*), and long-tailed salamanders (*Eurycea longicauda*) were not documented in previous surveys on either tract (VDGIF 1999). Due to strong similarities in the two dusky salamanders (*D. ochrophaeus* and *D. fuscus*), identification via our photographs was not possible for ALL captures. Therefore, captures were summed for the two species.

Table 4. Capture results by species for salamander surveys completed in May, 2013 at both tracts (MAIN: Main Plant; NRU: New River Unit) of the Radford Army Ammunition Plant. Species with an (*) were not documented in 1999 report.

Scientific Name	Common name	RFAAP Unit	No. captured
Eurycea longicauda	Long-tailed salamander*	NRU	3
		MAIN	1
Eurycea cirrigera	Southern two-lined salamander	NRU	1
		MAIN	1
Plethodon cylindraceus	Slimy salamander	NRU	0
		MAIN	2
Pseudotriton ruber	Northern red salamander*	NRU	1
		MAIN	1

Scientific Name	Common name	RFAAP Unit	No. captured
Desmognathus montanus	Grey-cheeked salamander*	NRU	0
		MAIN	1
Desmognathus ochrophaeus & *Desmognathus fuscus*	Allegheny Mountain dusky salamander* & northern dusky salamander	NRU	1
		MAIN	12

Figure 3. Examples of species captured in salamander surveys in May, 2013: A) Allegheny Mountain dusky salamander, B) Southern two-lined salamander, C) Long-tailed salamander, D) Northern red salamander, and E) Slimy salamander.

Birds

Methods—On 15 May and 11 July 2013 we assisted biologist Len DiIoia and avian specialist Clyde Kessler in surveys of birds on the New river unit. Special attention was paid to detecting Henslow's sparrows (*Ammodramus henslowii*), and callbacks were played at ideal sparrow locales.

Results—We identified 68 species across two survey days. No Henslow's sparrows were documented in our surveys. However, a complete list of species detected on each day is provided in Table 5. Additionally, a red-headed woodpecker was observed in flight during the small mammal surveys (June 2013) on the Main Plant.

Table 5. Species list for birds observed in May and July surveys, 2013. So that a single bird species list can be presented in one table, detection of birds via wildlife cameras also is included below.

Common name	Survey 5/13/2013	Survey 7/11/2013	Wildlife Cameras
American crow	X	X	X
American goldfinch	X	X	
American kestrel	X		

Source: September 2013. Animal Surveys at the Radford Army Ammunition Plant, 2012-2013. (Radford University)

Common name	Survey 5/13/2013	Survey 7/11/2013	Wildlife Cameras
American redstart	X		
American robin	X	X	X
Barn swallow	X	X	
Black-and-white warbler	X		
Black vulture	X		X
Blue-grey gnatcatcher	X		
Blue grosbeak	X	X	
Blue jay	X	X	X
Bobolink	X		
Brown thrasher	X	X	
Brown-headed cowbird	X	X	
Carolina chickadee	X		
Carolina wren	X	X	
Cedar waxwing	X	X	
Chimney swift	X	X	
Chipping sparrow	X	X	
Common grackle	X	X	
Common raven			X
Common yellowthroat	X		
Double-crested cormorant			X
Downy woodpecker	X		
Eastern bluebird	X	X	
Eastern kingbird	X	X	
Eastern meadowlark	X		
Eastern peewee	X	X	
Eastern phoebe	X		
Eastern towhee	X	X	
European starling	X		
Field Sparrow	X	X	
Grasshopper sparrow	X		
Great blue heron		X	X
Green heron	X		X
Hairy woodpecker	X	X	
Horned lark	X		
House wren	X	X	
Indigo bunting	X	X	
Killdeer	X		
Mallard			X

Source: September 2013. Animal Surveys at the Radford Army Ammunition Plant, 2012-2013. (Radford University)

Common name	Survey 5/13/2013	Survey 7/11/2013	Wildlife Cameras
Mourning dove	X	X	X
Northern bobwhite	X		
Northern cardinal	X	X	X
Northern flicker	X	X	X
Northern mockingbird	X	X	
Northern rough-winged swallow	X		
Orchard oriole	X	X	
Ovenbird	X		
Palm warbler	X		
Peregrine falcon	(probable ID)		
Pine warbler	X		
Pileated woodpecker	X		X
Prairie warbler	X	X	
Purple martin		X	
Red-bellied woodpecker	X	X	
Red-breasted nuthatch	X		
Red-headed woodpecker	Observed outside of formal surveys		
Red-eyed vireo		X	
Red-tailed hawk		X	X
Red-winged blackbird	X	X	X
Ruby-throated hummingbird		X	
Scarlet tanager	X		
Solitary sandpiper	X		
Song sparrow	X	X	
Spotted sandpiper	X		
Tufted titmouse	X		
Turkey vulture	X	X	X
Wild turkey	X	X	X
Wood thrush		X	
Yellow-breasted chat	X	X	

Turtles

Methods/Results— In late May 2013, on the New River Unit of RFAAP, eight turtle hoop traps were deployed at three sites – the “Pwamp” (4 traps), Pond2 (2 traps), and the Fishing Pond (2 traps). In 48 h of trapping, we captured one painted turtle (*Chrysemys picta*). This individual was located at the Pwamp site, and was missing all digits on its left front claw (Figure 4a).

Box turtles (*Terrapene carolina;* Figure 4b) also were documented on both tracts, but were not targeted in this aquatic-based survey. While painted turtles were viewed at other sites on both properties (e.g., hatching painted turtle discovered during small mammal trapping at "The Walls" on Main Plant; Figure 4c), no additional individuals were captured.

Figure 4. Examples of individuals captured in turtle surveys in May and June, 2013: A) Painted turtle caught in hoop trap, B) Box turtle found on road, C) Hatchling painted turtle caught on small mammal trapping line.

Butterflies

Methods/Results— Concurrent with the bird surveys, we assisted biologist Len DiIoia and butterfly specialist Clyde Kessler in surveys for the Regal Fritillary (*Speyeria idalia*). Although common butterfly species were detected in substantial numbers (e.g., cabbage white [*Pieris rapae*], eastern-tailed blue [*Cupio comyntas*], clouded sulphur [*Colias philodice*]), the regal fritillary was not detected. Diioia and Kessler kept exact tallies of species discovered, so no quantitative data are presented in this report.

Camera traps

Methods/Results— Eight camera traps have been deployed on the New River Unit since August 2012, and seven of them continue to collect photographs for us. To date, over 160,000 photos have been examined, and all species identified. In February and April, 2013, RU students Devon Silva and Nikohl Miller presented results of surveys through the first 6 months of the study, assessing over 70,000 photographs at the time. A copy of the PowerPoint presentation from April 2013 is included in Appendix 2. A list of bird species identified through this method is included in Table 5. Of note is the double-crested cormorant, which was photographed at the "pwamp" site on the New River Unit. This is the first time this species has been documented on the property.

A list of mammalian species identified in this survey is presented in Table 6. Species of note include the black bear (*Ursus americanus*), which has been documented at multiple locations in July 2013. The documentation at multiple sites over several weeks suggests that this bear (or bears) may not be a transient on the New River Unit. Also present in substantial number (especially in winter and spring months) is the coyote (*Canis latrans*), which was not detected in surveys a decade ago. Southern flying squirrels (*Glaucomys volans*) had taken over a nuthatch nest box at 37˚06' 6.8" N, 80˚38' 46.8" W, although we could not confirm that they were raising young in the box.

Noticeably missing was the red fox (*Vulpes vulpes*), which had been tentatively documented in previous surveys (Convery and Klopfer 2003). However, red foxes have been seen on both tracts in the past decade (L. DiIoia [RFAAP] and B. Stinson [VDGIF], personal communication). Future camera efforts might focus on ideal habitats for this species. For additional information on behavioral studies and relative abundance of species, please see Appendix 2.

Table 6. List of mammalian species identified via camera trap surveys, August 2012-August 2013. Surveys are on-going on the New River Unit of the Radford Army Ammunition Plant. Species with an (*) were not documented in 1999 report.

Order/Family	Scientific Name	Common Name
Artiodactyla/Cervidae	*Odocoileus virginianus*	White-tailed deer
Carnivora/Canidae	*Canis latrans**	Coyote
Carnivora/Canidae	*Canis lupus familiaris**	Domestic dog
Carnivora/Canidae	*Urocyon cinereoargenteus*	Grey fox
Carnivora/Felidae	*Felis catus**	Feral cat
Carnivora/Mephitidae	*Mephitis mephitis*	Striped skunk
Carnivora/Mustelidae	*Neovison vison**	American mink
Carnivora/Procyonidae	*Procyon lotor*	Raccoon
Carnivora/Ursidae	*Ursus americanus*	American black bear
Didelphimorphia/Didelphidae	*Didelphis virginiana*	Virginia opossum
Lagomorpha/Leporidae	*Sylvilagus floridanus*	Eastern cottontail
Rodentia/Cricetidae	*Ondatra zibethicus**	Muskrat
Rodentia/Sciuridae	*Sciurus niger*	Fox squirrel
Rodentia/Sciuridae	*Sciurus carolinensis*	Grey squirrel
Rodentia/Sciuridae	*Marmota monax*	Groundhog
Rodentia/Sciuridae	*Glaucomys volans**	Southern flying squirrel

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Literature Cited

Convery, K.M., and S.D. Klopfer. 2003. Final report: nest predator habitat use and evaluation of survey techniques at the Radford Army Ammunition Plant. CMI Publication No. CMI-GRS-03-03. Submitted December 17, 2003 by Conservation Management Institute, Blacksburg, VA. 36 pp.

VDGIF. 1999. Biological Survey of the Radford Army Ammunition Plant; including threatened, endangered, and species of concern. Virginia Department of Game and Inland Fisheries, Verona, VA. 86 pp. + appendices.

Appendix 1. Coordinates (latitude/longitude, degrees-minutes-seconds) for sites surveyed in summer 2013. Project column indicates taxon surveys in which this site was used. Both tracts (MAIN: Main Plant; NRU: New River Unit) of the Radford Army Ammunition Plant were surveyed.

Project	Tract	Site Name	Latitude (N)	Longitude (W)
Frogs	NRU	Sinkhole	37° 06' 24.4"	80° 40' 06.6"
Frogs	NRU	Fen	37° 05' 37.0"	80° 40' 08.7"
Frogs	NRU	Roadside ditch	37° 05' 59.0"	80° 39' 37.9"
Frogs	NRU	Food plot drainage	37° 06' 25.2"	80° 39' 03.1”
Frogs	NRU	Creek by 52	37° 06’ 45.2”	80° 38’ 25.1”
Frogs	NRU	Sneezeweed	37° 05' 36.7"	80° 39' 05.5"
Frogs	NRU	Firewater	37° 06' 04.7"	80° 39' 47.9”
Frogs/Mammals/Turtles	NRU	Pwamp	37° 05’ 40.5”	80° 40’ 19.1”
Frogs/Mammals/Turtles	NRU	Pond2 (& food plot)	37° 06’ 0.2”	80° 39’ 40.9”
Frogs/Mammals/Turtles	NRU	Fishing pond	37° 06’ 38.1”	80° 39’ 0.5”
Mammals	NRU	Grassland/Burn field	37° 05’ 41.4”	80° 39’ 57.1”
Mammals	NRU	Ephemeral stream	37°06’ 36.6”	80° 38’ 38.9”
Mammals	NRU	Hardwood/open (bear)	37° 06’ 08.6”	80° 38’ 31.1”
Frogs	Main	TNT swamp	37° 10’ 38.3”	80° 31' 35.3”
Frogs	Main	Peeper marsh	37° 11’ 17.2”	80° 31' 09.2”
Frogs	Main	Ghost’s haunt	37° 11’ 56.2”	80° 31' 14.0”
Frogs	Main	Pier pond	37° 11’ 16.0”	80° 33' 10.1”
Frogs/Mammals	Main	Walls	37° 11’ 23.5”	80° 31' 0.8”
Mammals	Main	Train tracks	37°12’ 01.1”	80° 32’ 49.4”
Mammals	Main	Frog marsh	37° 11’ 55.4”	80° 31’ 15.2”
Mammals	Main	Hardwood roadside	37° 11’ 44.1”	80° 32’ 13.1”
Mammals	Main	Open grassland	37° 11’ 55.7”	80° 31’ 45.4”
Mammals	Main	Stream	37° 10’ 47.8”	80° 31’ 38.5”

Appendix 2. PowerPoint presentation delivered in April 2013 by Radford University students Devon Silva and Nikohl Miller. Presentation included results from August 2012 – February 2013 camera trap surveys, and related behavioral studies.

Source: 1998 Biological Survey of RFAAP Including Threatened, Endangered, and Species of Concern.
(Virginia Department of Game and Inland Fisheries)

TAXA LISTS FOR THE MAIN FACILITY, RAAP

PLANTS

General Groups	Family	Scientific Name
Pteridophytes		*Adiantum pedatum*
Pteridophytes		*Asplenium platyneuron*
Pteridophytes		*Asplenium resiliens*
Pteridophytes		*Asplenium rhizophyllum*
Pteridophytes		*Asplenium ruta-muraria*
Pteridophytes		*Asplenium trichomanes*
Pteridophytes		*Athyrium felix-femina*
Pteridophytes		*Botrychium dissectum*
Pteridophytes		*Botrychium virginianum*
Pteridophytes		*Cystopteris bulbifera*
Pteridophytes		*Cystopteris protrusa*
Pteridophytes		*Cystopteris tennesseensis*
Pteridophytes		*Dennstaedtia punctilobula*
Pteridophytes		*Deparia acrostichoides*
Pteridophytes		*Diphasiastrum digitatum*
Pteridophytes		*Diplazium pycnocarpon*
Pteridophytes		*Dryopteris carthusiana*
Pteridophytes		*Dryopteris intermedia*
Pteridophytes		*Dryopteris marginalis*
Pteridophytes		*Equisetum arvense*
Pteridophytes		*Equisetum hyemale*
Pteridophytes		*Huperzia lucidula*
Pteridophytes		*Onoclea sensibilis*
Pteridophytes		*Osmunda cinnamomea*
Pteridophytes		*Osmunda claytoniana*
Pteridophytes		*Pellaea atropurpurea*
Pteridophytes		*Pellaea glabella*
Pteridophytes		*Phegopteris hexagonoptera*
Pteridophytes		*Polypodium appalachianum*
Pteridophytes		*Polypodium virginianum*
Pteridophytes		*Polystichum acrostichoides*
Pteridophytes		*Pteridium aquilinum*
Pteridophytes		*Thelypteris noveboracensis*
Pteridophytes		*Woodsia obtusa*
Monocots	Typhaceae	*Typha latifolia*
Monocots	Potamogetonaceae	*Potamogeton illinoensis*
Monocots	Potamogetonaceae	*Potamogeton nodosus*
Monocots	Potamogetonaceae	*Potamogeton pusillus*
Monocots	Alismataceae	*Sagittaria latifolia*
Monocots	Alismataceae	*Sagittaria rigida*
Monocots	Hydrocharitaceae	*Elodea canadensis*

Monocots	Poaceae	*Agrostis perennans*
Monocots	Poaceae	*Andropogon virginicus*
Monocots	Poaceae	*Aristida oligantha*
Monocots	Poaceae	*Aristida purpurascens*
Monocots	Poaceae	*Arrhenatherum elatius*
Monocots	Poaceae	*Arthraxon hispidus*
Monocots	Poaceae	*Bouteloua curtipendula*
Monocots	Poaceae	*Brachyelytrum erectum*
Monocots	Poaceae	*Bromus latiglumis*
Monocots	Poaceae	*Bromus nottowayanus*
Monocots	Poaceae	*Bromus pubescens*
Monocots	Poaceae	*Bromus racemosus*
Monocots	Poaceae	*Bromus sterilis*
Monocots	Poaceae	*Bromus tectorum*
Monocots	Poaceae	*Chasmanthium latifolium*
Monocots	Poaceae	*Cinna arundinacea*
Monocots	Poaceae	*Cynodon dactylon*
Monocots	Poaceae	*Danthonia compressa*
Monocots	Poaceae	*Danthonia spicata*
Monocots	Poaceae	*Dichanthelium acuminatum*
Monocots	Poaceae	*Dichanthelium boscii*
Monocots	Poaceae	*Dichanthelium clandestinum*
Monocots	Poaceae	*Dichanthelium commutatum*
Monocots	Poaceae	*Dichanthelium depauperatum*
Monocots	Poaceae	*Dichanthelium dichotomum var.*
Monocots	Poaceae	*Dichanthelium linearifolium*
Monocots	Poaceae	*Dichanthelium oligosanthes var.*
Monocots	Poaceae	*Digitaria ischaemum*
Monocots	Poaceae	*Digitaria sanguinalis*
Monocots	Poaceae	*Echinochloa crusgali*
Monocots	Poaceae	*Echinochloa muricata*
Monocots	Poaceae	*Eleusine indica*
Monocots	Poaceae	*Elymus hystrix*
Monocots	Poaceae	*Elymus riparius*
Monocots	Poaceae	*Elymus villosus*
Monocots	Poaceae	*Elymus virginicus*
Monocots	Poaceae	*Eragrostis capillaris*
Monocots	Poaceae	*Eragrostis cilianensis*
Monocots	Poaceae	*Eragrostis frankii*
Monocots	Poaceae	*Eragrostis hypnoides*
Monocots	Poaceae	*Eragrostis pectinacea*
Monocots	Poaceae	*Eragrostis spectabilis*
Monocots	Poaceae	*Festuca elatior*
Monocots	Poaceae	*Festuca obtusa*
Monocots	Poaceae	*Glyceria striata*
Monocots	Poaceae	*Leersia oryzoides*
Monocots	Poaceae	*Leersia virginica*

Monocots	Poaceae	*Leptoloma cognata*
Monocots	Poaceae	*Melica mutica*
Monocots	Poaceae	*Microstegium vimineum*
Monocots	Poaceae	*Muhlenbergia frondosa*
Monocots	Poaceae	*Muhlenbergia schreberi*
Monocots	Poaceae	*Muhlenbergia sobolifera*
Monocots	Poaceae	*Muhlenbergia sylvatica*
Monocots	Poaceae	*Muhlenbergia tenuiflora*
Monocots	Poaceae	*Oryzopsis racemosa*
Monocots	Poaceae	*Panicum anceps*
Monocots	Poaceae	*Panicum capillare var. sylvaticum*
Monocots	Poaceae	*Panicum dichotomiflorum*
Monocots	Poaceae	*Paspalum laeve*
Monocots	Poaceae	*Paspalum pubiflorum*
Monocots	Poaceae	*Paspalum setaceum*
Monocots	Poaceae	*Phalaris arundinacea*
Monocots	Poaceae	*Poa compressa*
Monocots	Poaceae	*Poa cuspidata*
Monocots	Poaceae	*Poa pratensis*
Monocots	Poaceae	*Poa sylvestris*
Monocots	Poaceae	*Poa trivialis*
Monocots	Poaceae	*Schizachyrium scoparium*
Monocots	Poaceae	*Setaria faberi*
Monocots	Poaceae	*Setaria geniculata*
Monocots	Poaceae	*Setaria glauca*
Monocots	Poaceae	*Setaria viridis*
Monocots	Poaceae	*Sorghastrum nutans*
Monocots	Poaceae	*Sorghum halepense*
Monocots	Poaceae	*Sphenopholis intermedia*
Monocots	Poaceae	*Sphenopholis nitida*
Monocots	Poaceae	*Sporobolus vaginiflorus (incl.*
Monocots	Poaceae	*Tridens flavus*
Monocots	Cyperaceae	*Carex aggregata*
Monocots	Cyperaceae	*Carex albicans*
Monocots	Cyperaceae	*Carex albursina*
Monocots	Cyperaceae	*Carex annectens*
Monocots	Cyperaceae	*Carex appalachica*
Monocots	Cyperaceae	*Carex blanda*
Monocots	Cyperaceae	*Carex cephalophora*
Monocots	Cyperaceae	*Carex cherokeensis*
Monocots	Cyperaceae	*Carex communis*
Monocots	Cyperaceae	*Carex conjuncta*
Monocots	Cyperaceae	*Carex copulata*
Monocots	Cyperaceae	*Carex digitalis*
Monocots	Cyperaceae	*Carex eburnea*
Monocots	Cyperaceae	*Carex frankii*
Monocots	Cyperaceae	*Carex granularis*

Monocots	Cyperaceae	*Carex grisea*
Monocots	Cyperaceae	*Carex hirsutella*
Monocots	Cyperaceae	*Carex hirtifolia*
Monocots	Cyperaceae	*Carex hitchcockiana*
Monocots	Cyperaceae	*Carex hystericina*
Monocots	Cyperaceae	*Carex jamesii*
Monocots	Cyperaceae	*Carex laevivaginata*
Monocots	Cyperaceae	*Carex laxiculmis*
Monocots	Cyperaceae	*Carex laxiflora*
Monocots	Cyperaceae	*Carex leptalea*
Monocots	Cyperaceae	*Carex lurida*
Monocots	Cyperaceae	*Carex nigromarginata*
Monocots	Cyperaceae	*Carex normalis*
Monocots	Cyperaceae	*Carex oligocarpa*
Monocots	Cyperaceae	*Carex pedunculata*
Monocots	Cyperaceae	*Carex pensylvanica*
Monocots	Cyperaceae	*Carex platyphylla*
Monocots	Cyperaceae	*Carex prasina*
Monocots	Cyperaceae	*Carex radiata*
Monocots	Cyperaceae	*Carex rosea*
Monocots	Cyperaceae	*Carex rugosperma*
Monocots	Cyperaceae	*Carex scoparia*
Monocots	Cyperaceae	*Carex shortiana*
Monocots	Cyperaceae	*Carex sparganioides*
Monocots	Cyperaceae	*Carex spicata*
Monocots	Cyperaceae	*Carex swanii*
Monocots	Cyperaceae	*Carex torta*
Monocots	Cyperaceae	*Carex tribuloides*
Monocots	Cyperaceae	*Carex umbellata*
Monocots	Cyperaceae	*Carex virescens*
Monocots	Cyperaceae	*Carex vulpinoidea*
Monocots	Cyperaceae	*Carex willdenowii*
Monocots	Cyperaceae	*Carex woodii*
Monocots	Cyperaceae	*Cyperus bipartitus*
Monocots	Cyperaceae	*Cyperus esculentus*
Monocots	Cyperaceae	*Cyperus flavescens*
Monocots	Cyperaceae	*Cyperus lancastriensis*
Monocots	Cyperaceae	*Cyperus lupulinus*
Monocots	Cyperaceae	*Cyperus odoratus*
Monocots	Cyperaceae	*Cyperus squarrosus*
Monocots	Cyperaceae	*Cyperus strigosus*
Monocots	Cyperaceae	*Cyperus tenuifolius*
Monocots	Cyperaceae	*Eleocharis erythropoda*
Monocots	Cyperaceae	*Eleocharis intermedia*
Monocots	Cyperaceae	*Eleocharis obtusa*
Monocots	Cyperaceae	*Schoenoplectus pungens*
Monocots	Cyperaceae	*Schoenoplectus validus*

Monocots	Cyperaceae	*Scirpus atrovirens*
Monocots	Cyperaceae	*Scirpus cyperinus*
Monocots	Cyperaceae	*Scirpus pendulus*
Monocots	Cyperaceae	*Trichophorum planifolium*
Monocots	Araceae	*Acorus calamus*
Monocots	Araceae	*Arisaema dracontium*
Monocots	Araceae	*Arisaema triphyllum*
Monocots	Araceae	*Symplocarpus foetidus*
Monocots	Lemnaceae	*Lemna minor*
Monocots	Commelinaceae	*Commelina communis*
Monocots	Commelinaceae	*Murdannia keisak*
Monocots	Commelinaceae	*Tradescantia ohiensis*
Monocots	Pontederiaceae	*Heteranthera dubia*
Monocots	Juncaceae	*Juncus articulatus*
Monocots	Juncaceae	*Juncus biflorus*
Monocots	Juncaceae	*Juncus brachycephalus*
Monocots	Juncaceae	*Juncus dudleyi*
Monocots	Juncaceae	*Juncus effusus*
Monocots	Juncaceae	*Juncus tenuis*
Monocots	Juncaceae	*Luzula acuminata*
Monocots	Juncaceae	*Luzula echinata*
Monocots	Liliaceae	*Allium canadense*
Monocots	Liliaceae	*Allium cernuum*
Monocots	Liliaceae	*Allium vineale*
Monocots	Liliaceae	*Asparagus officinalis*
Monocots	Liliaceae	*Disporum lanuginosum*
Monocots	Liliaceae	*Erythronium umbillicatum*
Monocots	Liliaceae	*Hemerocallis fulva*
Monocots	Liliaceae	*Lilium michauxii? (vegetative)*
Monocots	Liliaceae	*Melanthium hybridum? (vegetative)*
Monocots	Liliaceae	*Ornithogalum umbellatum*
Monocots	Liliaceae	*Polygonatum biflorum*
Monocots	Liliaceae	*Smilacina racemosa*
Monocots	Liliaceae	*Smilax glauca*
Monocots	Liliaceae	*Smilax herbacea*
Monocots	Liliaceae	*Smilax pulverulenta*
Monocots	Liliaceae	*Smilax rotundifolia*
Monocots	Liliaceae	*Smilax tamnoides*
Monocots	Liliaceae	*Trillium grandiflorum*
Monocots	Liliaceae	*Uvularia grandifolia*
Monocots	Liliaceae	*Uvularia perfoliata*
Monocots	Liliaceae	*Yucca filamentosa*
Monocots	Amaryllidaceae	*Hypoxis hirsuta*
Monocots	Dioscoreaceae	*Dioscorea batatas*
Monocots	Dioscoreaceae	*Dioscorea villosa*
Monocots	Iridaceae	*Iris pseudacorus*
Monocots	Iridaceae	*Sisyrinchium angustifolium*

Monocots	Iridaceae	*Sisyrinchium atlanticum*
Monocots	Orchidaceae	*Aplectrum hyemale*
Monocots	Orchidaceae	*Cypripedium acaule*
Monocots	Orchidaceae	*Goodyera pubescens*
Monocots	Orchidaceae	*Isotria verticillata*
Monocots	Orchidaceae	*Orchis spectabilis*
Monocots	Orchidaceae	*Spiranthes gracilis*
Dicots	Urticaceae	*Boehmeria cylindrica*
Dicots	Urticaceae	*Laportea canadensis*
Dicots	Urticaceae	*Parietaria pensylvanica*
Dicots	Urticaceae	*Pilea pumila*
Dicots	Urticaceae	*Urtica gracilis*
Dicots	Aristolochiaceae	*Aristolochia macrophylla*
Dicots	Aristolochiaceae	*Aristolochia serpentaria*
Dicots	Aristolochiaceae	*Asarum canadense*
Dicots	Polygonaceae	*Polygonum cespitosum*
Dicots	Polygonaceae	*Polygonum hydropiper*
Dicots	Polygonaceae	*Polygonum persicaria*
Dicots	Polygonaceae	*Polygonum punctatum*
Dicots	Polygonaceae	*Polygonum scandens*
Dicots	Polygonaceae	*Polygonum virginianum*
Dicots	Polygonaceae	*Rumex obtusifolius*
Dicots	Chenopodiaceae	*Chenopodium album*
Dicots	Chenopodiaceae	*Chenopodium ambrosoides*
Dicots	Chenopodiaceae	*Chenopodium standleynum*
Dicots	Phytolaccaceae	*Phytolacca americana*
Dicots	Aizoaceae	*Mollugo verticillata*
Dicots	Portulacaceae	*Claytonia virginica*
Dicots	Caryophyllaceae	*Arenaria serpyllifolia*
Dicots	Caryophyllaceae	*Cerastium fontanum*
Dicots	Caryophyllaceae	*Cerastium nutans*
Dicots	Caryophyllaceae	*Dianthus armeria*
Dicots	Caryophyllaceae	*Myosoton aquaticum*
Dicots	Caryophyllaceae	*Paronychia canadensis*
Dicots	Caryophyllaceae	*Saponaria officinalis*
Dicots	Caryophyllaceae	*Silene antirrhina*
Dicots	Caryophyllaceae	*Silene stellata*
Dicots	Caryophyllaceae	*Silene virginica*
Dicots	Caryophyllaceae	*Stellaria longifolia*
Dicots	Caryophyllaceae	*Stellaria media*
Dicots	Caryophyllaceae	*Stellaria pubera*
Dicots	Ranunculaceae	*Anemone lancifolia*
Dicots	Ranunculaceae	*Anemone quinquifolia*
Dicots	Ranunculaceae	*Anemone virginiana*
Dicots	Ranunculaceae	*Aquilegia canadensis*
Dicots	Ranunculaceae	*Cimicifuga racemosa*
Dicots	Ranunculaceae	*Clematis coactilis*

Dicots	Ranunculaceae	*Clematis viorna*
Dicots	Ranunculaceae	*Clematis virginiana*
Dicots	Ranunculaceae	*Delphinium tricorne*
Dicots	Ranunculaceae	*Hepatica acutiloba*
Dicots	Ranunculaceae	*Hepatica americana*
Dicots	Ranunculaceae	*Hydrastis canadensis*
Dicots	Ranunculaceae	*Ranunculus abortivus*
Dicots	Ranunculaceae	*Ranunculus alleghaniensis*
Dicots	Ranunculaceae	*Ranunculus recurvatus*
Dicots	Ranunculaceae	*Ranunculus repens*
Dicots	Ranunculaceae	*Thalictrum coriaceum*
Dicots	Ranunculaceae	*Thalictrum dioicum*
Dicots	Ranunculaceae	*Thalictrum thalictroides*
Dicots	Berberidaceae	*Caulophyllum thalictroides*
Dicots	Berberidaceae	*Jeffersonia diphylla*
Dicots	Berberidaceae	*Podophyllum peltatum*
Dicots	Menispermaceae	*Menispermum canadense*
Dicots	Fumariaceae	*Corydalis flavula*
Dicots	Papaveraceae	*Sanguinaria canadensis*
Dicots	Brassicaceae	*Alliaria petiolata*
Dicots	Brassicaceae	*Alyssum alyssoides*
Dicots	Brassicaceae	*Arabis canadensis*
Dicots	Brassicaceae	*Arabis laevigata*
Dicots	Brassicaceae	*Barbarea vulgaris*
Dicots	Brassicaceae	*Camelina microcarpa*
Dicots	Brassicaceae	*Cardamine hirsuta*
Dicots	Brassicaceae	*Cardamine pensylvanica*
Dicots	Brassicaceae	*Dentaria laciniata*
Dicots	Brassicaceae	*Draba ramosissima*
Dicots	Brassicaceae	*Hesperis matronalis*
Dicots	Brassicaceae	*Lepidium campestre*
Dicots	Brassicaceae	*Lepidium virginicum*
Dicots	Brassicaceae	*Nasturtium officinale*
Dicots	Brassicaceae	*Rorippa palustris*
Dicots	Brassicaceae	*Rorippa sylvestris*
Dicots	Brassicaceae	*Sisymbrium altissimum*
Dicots	Brassicaceae	*Thlaspi perfoliata*
Dicots	Podostemonaceae	*Podostemum ceratophyllum*
Dicots	Crassulaceae	*Penthorum sedioides*
Dicots	Crassulaceae	*Sedum glaucophyllum*
Dicots	Crassulaceae	*Sedum ternatum*
Dicots	Saxifragaceae	*Heuchera americana*
Dicots	Saxifragaceae	*Heuchera villosa*
Dicots	Saxifragaceae	*Mitella diphylla*
Dicots	Saxifragaceae	*Saxifraga virginiensis*
Dicots	Rosaceae	*Agrimonia parviflora*
Dicots	Rosaceae	*Agrimonia pubescens*

Dicots	Rosaceae	*Agrimonia rostellata*
Dicots	Rosaceae	*Duchesnia indica*
Dicots	Rosaceae	*Geum canadense*
Dicots	Rosaceae	*Potentilla canadensis*
Dicots	Rosaceae	*Potentilla simplex*
Dicots	Rosaceae	*Rubus alleghaniensis*
Dicots	Rosaceae	*Rubus flagellaris*
Dicots	Rosaceae	*Rubus occidentalis*
Dicots	Rosaceae	*Rubus phoenicalasius*
Dicots	Fabaceae	*Amphicarpa bracteata*
Dicots	Fabaceae	*Apios americana*
Dicots	Fabaceae	*Cassia marilandica*
Dicots	Fabaceae	*Desmodium canescens? (vegetative)*
Dicots	Fabaceae	*Desmodium paniculatum*
Dicots	Fabaceae	*Desmodium rotundifolium*
Dicots	Fabaceae	*Galactia volubilis*
Dicots	Fabaceae	*Kummerowia stipulacea*
Dicots	Fabaceae	*Kummerowia striata*
Dicots	Fabaceae	*Lespedeza cuneata*
Dicots	Fabaceae	*Lespedeza hirta*
Dicots	Fabaceae	*Lespedeza intermedia*
Dicots	Fabaceae	*Lespedeza procumbens*
Dicots	Fabaceae	*Lespedeza repens*
Dicots	Fabaceae	*Lespedeza virginica*
Dicots	Fabaceae	*Melilotus alba*
Dicots	Fabaceae	*Melilotus officinalis*
Dicots	Fabaceae	*Trifolium campestre*
Dicots	Fabaceae	*Trifolium pratense*
Dicots	Fabaceae	*Trifolium repens*
Dicots	Fabaceae	*Vicia caroliniana*
Dicots	Geraniaceae	*Geranium maculatum*
Dicots	Oxalidaceae	*Oxalis corniculata*
Dicots	Oxalidaceae	*Oxalis dillenii*
Dicots	Oxalidaceae	*Oxalis grandis*
Dicots	Oxalidaceae	*Oxalis stricta*
Dicots	Oxalidaceae	*Oxalis violacea*
Dicots	Polygalaceae	*Polygala pauciflora*
Dicots	Polygalaceae	*Polygala verticillata*
Dicots	Euphorbiaceae	*Acalypha rhomboidea*
Dicots	Euphorbiaceae	*Euphorbia commutata*
Dicots	Euphorbiaceae	*Euphorbia maculata*
Dicots	Euphorbiaceae	*Euphorbia nutans*
Dicots	Anacardiaceae	*Toxicodendron radicans*
Dicots	Celastraceae	*Celastrus orbiculatus*
Dicots	Celastraceae	*Celastrus scandens*
Dicots	Balsaminaceae	*Impatiens capensis*
Dicots	Balsaminaceae	*Impatiens pallida*

Dicots	Caprifoliaceae	*Triosteum perfoliatum*
Dicots	Dipsacaceae	*Dipsacus fullonum*
Dicots	Cucurbitaceae	*Sicyos angulatus*
Dicots	Campanulaceae	*Campanula americana*
Dicots	Campanulaceae	*Campanula divaricata*
Dicots	Campanulaceae	*Lobelia inflata*
Dicots	Campanulaceae	*Lobelia siphilitica*
Dicots	Campanulaceae	*Lobelia spicata var. scaposa*
Dicots	Campanulaceae	*Specularia perfoliata*
Dicots	Asteraceae	*Achillea millefolium*
Dicots	Asteraceae	*Ambrosia artemisiifolia*
Dicots	Asteraceae	*Antennaria parlinii ssp. Fallax*
Dicots	Asteraceae	*Antennaria parlinii ssp. parlinii*
Dicots	Asteraceae	*Antennaria plantaginifolia*
Dicots	Asteraceae	*Artemisia vulgaris*
Dicots	Asteraceae	*Aster cordifolius var. cordifolius*
Dicots	Asteraceae	*Aster cordifolius var. sagittifolius*
Dicots	Asteraceae	*Aster divaricatus*
Dicots	Asteraceae	*Aster laevis*
Dicots	Asteraceae	*Aster lanceolatus*
Dicots	Asteraceae	*Aster lateriflorus*
Dicots	Asteraceae	*Aster oblongifolius*
Dicots	Asteraceae	*Aster pilosus*
Dicots	Asteraceae	*Aster puniceus*
Dicots	Asteraceae	*Aster undulatus*
Dicots	Asteraceae	*Bidens bipinnata*
Dicots	Asteraceae	*Bidens cernua*
Dicots	Asteraceae	*Bidens frondosa*
Dicots	Asteraceae	*Bidens tripartita*
Dicots	Asteraceae	*Cacalia atriplicifolia*
Dicots	Asteraceae	*Carduus acanthoides*
Dicots	Asteraceae	*Carduus nutans*
Dicots	Asteraceae	*Centaurea dubia*
Dicots	Asteraceae	*Centaurea maculosa*
Dicots	Asteraceae	*Chrysanthemum leucanthemum*
Dicots	Asteraceae	*Cichorium intybus*
Dicots	Asteraceae	*Cirsium arvense*
Dicots	Asteraceae	*Cirsium discolor*
Dicots	Asteraceae	*Cirsium vulgare*
Dicots	Asteraceae	*Conoclinium coelestinum*
Dicots	Asteraceae	*Conyza canadensis*
Dicots	Asteraceae	*Coreopsis lanceolata*
Dicots	Asteraceae	*Coreopsis major*
Dicots	Asteraceae	*Crepis capillaris*
Dicots	Asteraceae	*Erechtites hieracifolia*
Dicots	Asteraceae	*Erigeron annuus*
Dicots	Asteraceae	*Erigeron philadelphicus*

Dicots	Asteraceae	*Erigeron pulchellus*
Dicots	Asteraceae	*Erigeron strigosus*
Dicots	Asteraceae	*Eupatorium fistulosum*
Dicots	Asteraceae	*Eupatorium perfoliatum*
Dicots	Asteraceae	*Eupatorium purpureum*
Dicots	Asteraceae	*Eupatorium rugosum*
Dicots	Asteraceae	*Eupatorium serotinum*
Dicots	Asteraceae	*Eupatorium sessilifolium*
Dicots	Asteraceae	*Galinsoga quadriradiata*
Dicots	Asteraceae	*Gnaphalium obtusifolium*
Dicots	Asteraceae	*Gnaphalium purpureum*
Dicots	Asteraceae	*Hasteola suaveolens*
Dicots	Asteraceae	*Helenium autumnale*
Dicots	Asteraceae	*Helianthus divaricatus*
Dicots	Asteraceae	*Heliopsis helianthoides*
Dicots	Asteraceae	*Hieracium pilosella*
Dicots	Asteraceae	*Hieracium pratense*
Dicots	Asteraceae	*Hieracium venosum*
Dicots	Asteraceae	*Hypochoeris radicata*
Dicots	Asteraceae	*Kuhnia eupatorioides*
Dicots	Asteraceae	*Lactuca canadensis*
Dicots	Asteraceae	*Lapsana communis*
Dicots	Asteraceae	*Polymnia canadensis*
Dicots	Asteraceae	*Polymnia uvedalia*
Dicots	Asteraceae	*Rudbeckia triloba*
Dicots	Asteraceae	*Rudbeckis laciniata*
Dicots	Asteraceae	*Senecio anonymous*
Dicots	Asteraceae	*Senecio aureus*
Dicots	Asteraceae	*Senecio obovatus*
Dicots	Asteraceae	*Senecio plattensis*
Dicots	Asteraceae	*Silphium perfoliatum var. connatum*
Dicots	Asteraceae	*Silphium trifoliatum*
Dicots	Asteraceae	*Solidago altissima*
Dicots	Asteraceae	*Solidago arguta*
Dicots	Asteraceae	*Solidago bicolor*
Dicots	Asteraceae	*Solidago canadensis var. hargeri*
Dicots	Asteraceae	*Solidago curtisii*
Dicots	Asteraceae	*Solidago flexicaulis*
Dicots	Asteraceae	*Solidago gigantea*
Dicots	Asteraceae	*Solidago nemoralis*
Dicots	Asteraceae	*Solidago rugosa*
Dicots	Asteraceae	*Solidago sphacelata*
Dicots	Asteraceae	*Solidago ulmifolia*
Dicots	Asteraceae	*Taraxacum officinale*
Dicots	Asteraceae	*Tragopogon dubius*
Dicots	Asteraceae	*Tussilago farfara*
Dicots	Asteraceae	*Verbesina alternifolia*

Dicots	Asteraceae	*Verbesina occidentalis*
Dicots	Asteraceae	*Vernonia noveboracensis*
Trees		*Juniperus virginiana*
Trees		*Pinus pungens*
Trees		*Pinus strobus*
Trees		*Pinus taeda*
Trees		*Pinus virginiana*
Trees		*Tsuga canadensis*
Trees	Salicaceae	*Populus alba*
Trees	Salicaceae	*Salix nigra*
Trees	Juglandaceae	*Carya cordiformis*
Trees	Juglandaceae	*Carya glabra*
Trees	Juglandaceae	*Carya ovata*
Trees	Juglandaceae	*Carya tomentosa*
Trees	Juglandaceae	*Juglans cinerea*
Trees	Juglandaceae	*Juglans nigra*
Trees	Betulaceae	*Betula lenta*
Trees	Betulaceae	*Carpinus caroliniana*
Trees	Betulaceae	*Ostrya virginiana*
Trees	Fagaceae	*Castanea dentata*
Trees	Fagaceae	*Fagus grandifolia*
Trees	Fagaceae	*Quercus alba*
Trees	Fagaceae	*Quercus coccinea*
Trees	Fagaceae	*Quercus falcata*
Trees	Fagaceae	*Quercus muhlenbergii*
Trees	Fagaceae	*Quercus prinus*
Trees	Fagaceae	*Quercus rubra*
Trees	Fagaceae	*Quercus shumardii*
Trees	Fagaceae	*Quercus velutina*
Trees	Ulmaceae	*Celtis occidentalis*
Trees	Ulmaceae	*Celtis tenuifolia*
Trees	Ulmaceae	*Ulmus americana*
Trees	Ulmaceae	*Ulmus rubra*
Trees	Moraceae	*Morus alba*
Trees	Magnoliaceae	*Liriodendron tulipifera*
Trees	Magnoliaceae	*Magnolia acuminata*
Trees	Lauraceae	*Sassafras albidum*
Trees	Platanaceae	*Platanus occidentalis*
Trees	Rosaceae	*Amelanchier arborea*
Trees	Rosaceae	*Crataegus crusgali*
Trees	Rosaceae	*Prunus avium*
Trees	Rosaceae	*Prunus serotina*
Trees	Fabaceae	*Gleditsia triacanthos*
Trees	Fabaceae	*Robinia pseudoacacia*
Trees	Simarubaceae	*Ailanthus altissima*
Trees	Aceraceae	*Acer negundo*
Trees	Aceraceae	*Acer nigrum*

Source: 1998 Biological Survey of RFAAP Including Threatened, Endangered, and Species of Concern. (Virginia,Department of Game and Inland Fisheries)

Trees	Aceraceae	*Acer rubrum*
Trees	Aceraceae	*Acer saccharinum*
Trees	Aceraceae	*Acer saccharum*
Trees	Hippocastanaceae	*Aesculus flava*
Trees	Tiliaceae	*Tilia heterophylla*
Trees	Cornaceae	*Cornus florida*
Trees	Cornaceae	*Nyssa sylvatica*
Trees	Ericaceae	*Oxydendron arboreum*
Trees	Oleaceae	*Fraxinus americana*
Trees	Oleaceae	*Fraxinus pennsylvanica*
Trees	Scrophulariaceae	*Paulownia tomentosa*
Shrubs	Salicaceae	*Salix eriocephala*
Shrubs	Betulaceae	*Corylus americana*
Shrubs	Betulaceae	*Corylus cornuta*
Shrubs	Fagaceae	*Castanea pumila*
Shrubs	Berberidaceae	*Berberis canadensis*
Shrubs	Berberidaceae	*Berberis thunbergii*
Shrubs	Annonaceae	*Asimina triloba*
Shrubs	Lauraceae	*Lindera benzoin*
Shrubs	Saxifragaceae	*Hydrangea arborescens*
Shrubs	Hamamelidaceae	*Hamamelis virginiana*
Shrubs	Rosaceae	*Crataegus uniflora*
Shrubs	Rosaceae	*Physocarpus opulifolius*
Shrubs	Rosaceae	*Prunus alleghiensis/americana?*
Shrubs	Rosaceae	*Rosa carolina*
Shrubs	Rosaceae	*Rosa multiflora*
Shrubs	Fabaceae	*Cercis canadensis*
Shrubs	Rutaceae	*Ptelea trifoliata*
Shrubs	Anacardiaceae	*Rhus aromatica*
Shrubs	Anacardiaceae	*Rhus copalina*
Shrubs	Anacardiaceae	*Rhus glabra*
Shrubs	Anacardiaceae	*Rhus typhina*
Shrubs	Staphyleaceae	*Staphylea trifolia*
Shrubs	Rhamnaceae	*Rhamnus lanceolata*
Shrubs	Elaeagnaceae	*Elaeagnus umbellata*
Shrubs	Cornaceae	*Cornus alternifolia*
Shrubs	Cornaceae	*Cornus amomum*
Shrubs	Ericaceae	*Gaylussacia baccata*
Shrubs	Ericaceae	*Kalmia latifolia*
Shrubs	Ericaceae	*Rhododendron maximum*
Shrubs	Ericaceae	*Rhododendron periclymenoides*
Shrubs	Ericaceae	*Vaccinium pallidum*
Shrubs	Ericaceae	*Vaccinium stamineum*
Shrubs	Styracaceae	*Halesia carolina*
Shrubs	Oleaceae	*Chionanthus virginicus*
Shrubs	Caprifoliaceae	*Deutzia scabra*
Shrubs	Caprifoliaceae	*Lonicera maackii*

Shrubs	Caprifoliaceae	*Lonicera morrowii*
Shrubs	Caprifoliaceae	*Sambucus canadensis*
Shrubs	Caprifoliaceae	*Symphoricarpos orbiculatus*
Shrubs	Caprifoliaceae	*Viburnum acerifolium*
Shrubs	Caprifoliaceae	*Viburnum prunifolium*
Shrubs	Caprifoliaceae	*Viburnum rafinesquianum*
Shrubs	Caprifoliaceae	*Viburnum rufidulum*

INVERTEBRATES

Class: Arachnida
Order: Araneae

Family	Scientific Name	Common Name
Agelenidae	*Cicurina pallida*	
Agelenidae	*Cicurina robusta*	
Agelenidae	*Cicurina sp.*	
Agelenidae	*Coras medicinalis*	
Agelenidae	*Cryphoeca montana*	
Agelenidae	*Cybaeus sp.*	
Agelenidae	*Cybaeus unk.*	
Agelenidae	*sp.*	
Agelenidae	*Wadotes bimucronatus*	
Agelenidae	*Wadotes calcaratus*	
Agelenidae	*Wadotes hybridus*	
Agelenidae	*Wadotes sp*	
Agelenidae	*Wadotes sp.*	
Amaurobiidae	*sp.*	
Antrodiaetidae	*Antrodiaetus unicolor*	
Anyphaenidae	*Anyphaena celer*	
Anyphaenidae	*Anyphaena sp.*	
Araneidae	*Acanthepeira sp.*	
Araneidae	*Araneus pratensis*	
Araneidae	*Araneus marmoreus*	
Araneidae	*Cyclosa conica*	
Araneidae	*Eustala anastera*	
Araneidae	*Meta menardi*	
Araneidae	*Micrathena gracilis*	
Araneidae	*Micrthena mitrata*	
Araneidae	*Neoscona arabesca*	
Araneidae	*sp.*	
Araneidae	*Verrucosa arenata*	
Atypidae	*Sphodros niger*	
Clubionidae	*Agroeca minuta*	
Clubionidae	*Castianeira cingulata*	
Clubionidae	*Castianeira longipalpus*	
Clubionidae	*Castianeira variata*	

Clubionidae	*Clubiona obesa*	
Clubionidae	*Clubiona excepta*	
Clubionidae	*Clubiona sp.*	
Clubionidae	*sp.*	
Clubionidae	*Trachelas deceptus*	
Dictynidae	*Dictyna sp.*	
Dictynidae	*Dictyna sublata*	
Dysderidae	*Dysdera crocata*	
Gnaphosidae	*Callilepis pluto*	
Gnaphosidae	*Cesonia bilineata*	
Gnaphosidae	*Drassyllus aprilinus*	
Gnaphosidae	*Drassyllus creolus*	
Gnaphosidae	*Drassyllus depressus*	
Gnaphosidae	*Drassyllus fallens*	
Gnaphosidae	*Drassyllus novus*	
Gnaphosidae	*Drassyllus sp.*	
Gnaphosidae	*Haplodrassus sp.*	
Gnaphosidae	*Litopyllus temporarius*	
Gnaphosidae	*sp.*	
Gnaphosidae	*Zelotes duplex*	
Gnaphosidae	*Zelotes hentzi*	
Hahniidae	*Neoantistae agilis*	
Hahniidae	*Neoantistea magna*	
Linyphiidae	*Bathyphantes pallida*	
Linyphiidae	*Centromerus cornupalpis*	
Linyphiidae	*Lepthyphantes zebra*	
Linyphiidae	*Nereine variabilis*	
Linyphiidae	*Pityohyphantes costatus*	
Linyphiidae	*sp.*	
Linyphiidae	*Stemonypantes blauveltae*	
Linyphiidae	*Stemonyphantes blauveltae*	
Linyphiidae	*Tapinopa bilineata*	
Lycosidae	*Allocosa funerea*	
Lycosidae	*Arctosa virgo*	
Lycosidae	*Gladicosa gulosa*	
Lycosidae	*Hogna frondicola*	
Lycosidae	*Hogna punctulata*	
Lycosidae	*Hogna rabida*	
Lycosidae	*Hogna sp.*	
Lycosidae	*Pardosa sexatilis*	
Lycosidae	*Pardosa sp.*	
Lycosidae	*Pirata minutus*	
Lycosidae	*Pirata montanus*	
Lycosidae	*Pirata sedentarius*	
Lycosidae	*Schizocosa avida*	
Lycosidae	*Schizocosa bilineata*	
Lycosidae	*Schizocosa ocreata*	

Lycosidae	*Schizocosa ocreate*	
Lycosidae	*Schizocosa saltatrix*	
Lycosidae	*sp.*	
Lycosidae	*Varacosa avara*	
Mimetidae	*Mimetus epeiroides*	
Oxyopidae	*Oxyopes salticus*	
Philodromidae	*Ebo Latithorax*	
Philodromidae	*Philodromus minutus*	
Philodromidae	*Philodromus rufus*	
Philodromidae	*Thanatus rubicellus*	
Pisauridae	*Dolomedes sp.*	
Pisauridae	*Dolomedes triton*	
Pisauridae	*Pisaurina mira*	
Salticidae	*Eris marginata*	
Salticidae	*Eris sp.*	
Salticidae	*Evarcha hoyi*	
Salticidae	*Habrocestum pulex*	
Salticidae	*Hentzia mitrata*	
Salticidae	*Marpissa pikei*	
Salticidae	*Metaphidippus protervus*	
Salticidae	*Neon nellii*	
Salticidae	*Phidippus audax*	
Salticidae	*Phidippus sp.*	
Salticidae	*Phidippus whitmanii*	
Salticidae	*sp.*	
Salticidae	*Thiodina sylvana*	
Salticidae	*Zygoballus nervosus*	
Tetragnathidae	*Leucauge venusta*	
Tetragnathidae	*Pachygnatha autumnalis*	
Tetragnathidae	*Pachynatha furcillata*	
Tetragnathidae	*Tetragnatha elongata*	
Tetragnathidae	*Tetragnatha laborisoa*	
Tetragnathidae	*Tetragnatha sp.*	
Tetragnathidae	*Tetragnatha straminea*	
Tetragnathidae	*Tetragnatha unk1*	
Tetragnathidae	*Tetragnatha versicolor*	
Theridiidae	*Achaearanea globosa*	
Theridiidae	*Achaearanea porteri*	
Theridiidae	*Achaearanea rupicola*	
Theridiidae	*Achaearnea tepidariorum*	
Theridiidae	*Dipoena nigra*	
Theridiidae	*Enoplognatha marmorata*	
Theridiidae	*sp.*	
Theridiidae	*Steatoda americana*	
Theridiidae	*Theridion sp.*	
Theridiidae	*Thymoites sp.*	
Thomisidae	*Misumenops sp.*	

Thomisidae	*Xysticus bicuspis*	
Thomisidae	*Xysticus elegans*	
Thomisidae	*Xysticus ferox*	
Thomisidae	*Xysticus sp.*	
Thomisidae	*Xysticus unk.*	

Class: Bivalvia
Order: Unionoida

Family	Scientific Name	Common Name
Unionidae	*Cyclonaias tuberculata*	Purple wartyback
Unionidae	*Eliptio dilitata*	Spike
Unionidae	*Lampsilis fasciola*	Wavy ray lampmussel
Unionidae	*Lampsilis ovata*	Pocketbook
Unionidae	*Lasmigona subviridis*	Green floater
Unionidae	*Tritigonia verrucossa*	Pistol grip

Class: Bivalvia
Order: Veneroida

Family	Scientific Name	Common Name
Corbiculidae	*Corbicula fluminea*	Asian clam

Class Branchipoda
Order Cladocera

Specimen not identified beyond order.

Class: Chilopoda
Order: Scolopendro

Family	Scientific Name	Common Name
Cryptopidae	*Scolocryptops sexspinosus*	Centipede

Class: Diplopoda
Order: Julida

Family	Scientific Name	Common Name
Julidae	*Ophyiulus pilosus*	Millipede

Class: Diplopoda
Order Polydesmida

Family	Scientific Name	Common Name
Xystodesmidae	*Gyalostethus monticolens*	Millipede
Xystodesmidae	*Nannaria ericacea*	Millipede

Class: Gastropoda
Order: Architaenioglossa

Family	Scientific Name	Common Name
Vivaparidae	*Campeloma decisum*	Aquatic snail

Class: Gastropoda
Order: Basommatophora

Family	Scientific Name	Common Name
Ancylidae	*Ferrissia rivularis*	Aquatic snail
Planorbidae	*Helisoma anceps*	Aquatic snail
Physidae	*Physella gyrina*	Aquatic snail

Class: Gastropoda
Order: Neotaenioglossa

Family	Scientific Name	Common Name
Pleuroceridae	*Leptoxis dilatata*	Aquatic snail

Class: Insecta
Order: Coleoptera

Family	Scientific Name	Common Name
Cantharidae	*sp.*	Soldier beetle
Carabidae	*Agonum sp.*	Ground beetle
Carabidae	*Amphasia interstitialis*	Ground beetle
Carabidae	*Apenes lucidula*	Ground beetle
Carabidae	*Arisodactylus nigerrimus*	Ground beetle
Carabidae	*Chlaenius aestivus*	Ground beetle
Carabidae	*Chlaenius emarginatus*	Ground beetle
Carabidae	*Chlaenius impunctifrons*	Ground beetle
Carabidae	*Chlaenius nemoralis*	Ground beetle
Carabidae	*Clivina bipustulata*	Ground beetle
Carabidae	*Cyclotrachelus iuveuis*	Ground beetle
Carabidae	*Dicaelus dilatatus*	Ground beetle
Carabidae	*Dicaelus elongatus*	Ground beetle
Carabidae	*Dicaelus teter*	Ground beetle
Carabidae	*Lebia grandis*	Ground beetle
Carabidae	*Lebia viridis*	Ground beetle
Carabidae	*Oligthopus parmatus*	Ground beetle
Carabidae	*Poecilus sp.*	Ground beetle
Carabidae	*Pterostichus mutus*	Ground beetle
Carabidae	*Pterostichus sp.*	Ground beetle
Carabidae	*Pterostichus trinarius*	Ground beetle

Carabidae	*Rhadine caudata*	Ground beetle
Carabidae	*Scarites subterraneus*	Ground beetle
Carabidae	*Sphaeroderus stenostomus*	Ground beetle
Chrysomelidae	*Stenispa metallica*	Leaf beetle
Endomychidae	*Aphorista vittata*	Handsome fungus beetle
Lampyridae	*sp.*	Firefly
Lucanidae	*sp.*	Stag beetle
Meloidae	*Meloe angusticollis*	Blister beetle
Psephenidae	*sp.*	Water-penny beetle
Scarabaeidae	*Copris minutus*	Scarab beetle
Scarabaeidae	*Euphoria inda*	Scarab beetle
Scarabaeidae	*Phyllophaga sp.*	Scarab beetle
Staphylinidae	*Geodromicus brunneus*	Rove beetle
Staphylinidae	*Olophrum obtectum*	Rove beetle
Staphylinidae	*Pinophilus laticeps*	Rove beetle
Staphylinidae	*Platydraeus sp.*	Rove beetle

Class: Insecta
Order: Collembola

Family	Scientific Name	Common Name
Entomobryidae	*sp.*	Springtail
Hypogastruidae	*sp.*	Springtail
Sminthuridae	*sp.*	Springtail

Class: Insecta
Order: Diptera

Family	Scientific Name	Common Name
Acroceridae	*sp.*	Small-headed fly
Anthomyiidae	*sp.*	Anthomyiid fly
Asilidae	*sp.*	Robber fly
Blephariceridae	*sp.*	Net-winged midge
Cecidomyiidae	*sp.*	Gall gnat
Chironomidae	*sp.*	Midge
Chloropidae	*sp.*	Frit fly
Culicidae	*sp.*	Mosquito
Curtonotidae	*sp.*	Curtonotid fly
Dolichopodidae	*sp.*	Long-legged fly
Drosophilidae	*sp.*	Pomace fly
Empididae	*sp.*	Dance fly
Lauxaniidae	*sp.*	Lauxaniid fly
Muscidae	*sp.*	Muscid fly
Mycetophilidae	*sp.*	Fungus gnat
Phoridae	*sp.*	Humpbacked fly
Ptychopteridae	*sp.*	Phantom crane fly

Rhagionidae	*sp.*	Snipe fly
Scathophagidae	*sp.*	Scathophagid fly
Sciaridae	*sp.*	Dark-winged fungus gnat
Sepsidae	*sp.*	Scavenger fly
Simuliidae	*sp.*	Black fly
Syrphidae	*sp.*	Syrphid fly
Tabanidae	*sp.*	Deer fly
Tachinidae	*sp.*	Tachinid fly
Tephritidae	*sp.*	Fruit fly
Tipulidae	*sp.*	Crane fly
Xylophagidae	*sp.*	Xylophagid fly

Class: Insecta
Order: Ephemeroptera

Specimen not identified beyond order.

Class: Insecta
Order: Heteroptera

Family	Scientific Name	Common Name
Belostomatidae	*Belostoma fluminea*	Giant water bug
Lygalidae	*Cryphula trimaculata*	Seed bug
Miridae	*Lopidea robiniae*	Leaf bug
Pentatomidae	*Dendrocoris humeralis*	Stink bug
Psyllidae	*sp.*	Stink bug

Class: Insecta
Order: Homoptera

Family	*Scientific Name*	Common Name
Aphididae	*sp.*	Aphid
Cicadellidae	*sp.*	Leaf hopper

Class: Insecta
Order: Hymenoptera

Family	Scientific Name	Common Name
Braconidae	*sp.*	Brachonid
Chalcidoidea	*sp.*	Chalsid
Colletidae	*sp.*	Colletid bee
Formicidae	*Ambylopone pallipes*	Ponerinae (Ant)
Formicidae	*Campanotus sp.*	Formicinae (Ant)
Formicidae	*Formica sp.*	Formicinae (Ant)
Formicidae	*sp.*	Formicinae (Ant)
Formicidae	*sp.*	Myrmicinae (Ant)

Halictidae	*sp.*	Halictid bee
Ichneumonidae	*sp.*	Ichneumon
Pergidae	*sp.*	Pergid sawfly
Proctotrupoidea	*sp.*	Proctotrupids
Sphecidae	*sp.*	Sphecid wasp
Tenthredinidae	*sp.*	Common sawfly

Class: Insecta

Order: Lepidoptera

Family	Scientific Name	Common Name
Arctiidae	*Ecpantheria scribonia*	Giant Leopard Moth
Arctiidae	*Halysidota tessellaris*	Banded tussock moth
Arctiidae	*Haploa lecontei*	Leconte's haploa
Arctiidae	*Holomelina aurantiaca*	Orange holomelina
Arctiidae	*Holomelina opella*	Tawny Holomelina
Arctiidae	*Holomelina sp.*	Holomelina
Arctiidae	*Hypoprepia miniata*	Scarlet-winged lichen moth
Arctiidae	*Pyrrharctia isabella*	Isabella tiger moth
Arctiidae	*sp.*	Tiger moth
Arctiidae	*Spilisoma virginica*	Virginian tiger moth
Geometridae	*Biston betularia cognataria*	Pepper-and-Salt Geometer
Geometridae	*Campaea perlata*	Pale Beauty
Geometridae	*Ennomos magnaria*	Maple Spanworm Moth
Geometridae	*Euchlaena amoenaria*	Deep yellow euchlaena
Geometridae	*Eulithis diversilineata*	Lesser grapevine looper moth
Geometridae	*Heliomata cycladata*	Common spring moth
Geometridae	*Heterophleps triguttaria*	Three-spotted Fillip
Geometridae	*Lambdina pellucidaria*	Yellow-headed Looper Moth
Geometridae	*Nacophora quernaria*	Oak Beauty
Geometridae	*Orthonama centrostrigaria*	Bent-line Carpet
Geometridae	*Pobole sp.*	
Geometridae	*Semiothisa promiscuata*	Promiscuous angle
Geometridae	*Synchlora aerata*	Wavy-lined Emerald
Geometridae	*Trichodezia albovittata*	White-striped black
Geometridae	*Xanthotype sp.*	Crocus geometer
Hesperidae	*Amblyscirtes vialis*	Common roadside skipper
Hesperidae	*Ancyloxypha numitor*	Least skipper
Hesperidae	*Atalopedes campestris*	Sachem
Hesperidae	*Atrytone logan*	Delaware skipper
Hesperidae	*Atrytonopsis hianna*	Dusted skipper
Hesperidae	*Epargyreus clarus*	Silver-spotted skipper
Hesperidae	*Erynnis baptisiae*	Wild indigo duskywing
Hesperidae	*Erynnis brizo*	Sleepy duskywing
Hesperidae	*Erynnis horatius*	Horace's duskywing
Hesperidae	*Erynnis icelus*	Dreamy duskywing
Hesperidae	*Erynnis juvenalis*	Juvena'ls duskywing

Hesperidae	*Euphyes vestris*	Dun skipper
Hesperidae	*Hylephila phyleus*	Fiery skipper
Hesperidae	*Lerema accius*	Clouded skipper
Hesperidae	*Nastra iherminier*	Swarthy skipper
Hesperidae	*Panaquina ocola*	Ocola skipper
Hesperidae	*Poanes hobomok*	Hobomok skipper
Hesperidae	*Poanes zabulon*	Zabulon skipper
Hesperidae	*Polites origenes*	Crossline skipper
Hesperidae	*Polites peckius*	Peck's skipper
Hesperidae	*Polites themistocles*	Tawny-edged skipper
Hesperidae	*Pompeius verna*	Little glassywing
Hesperidae	*Pyrgus communis*	Common checkered skipper
Hesperidae	*Thorybes bathyllus*	Southern cloudywing
Hesperidae	*Thorybes pylades*	Northern cloudywing
Hesperidae	*Thymelicus lineola*	European skipper
Hesperidae	*Wallengrenia egeremet*	Northern broken dash
Lasiocampidae	*Artace cribraria*	Dot-lined White
Lasiocampidae	*Malacosoma americanum*	Tent caterpillar
Lasiocampidae	*Malacosoma disstria*	Forest tent caterpillar moth
Limacodidae	*Packardia geminata*	Slug caterpillar moth
Lycaenidae	*Callophrys gryneus*	Olive hairstreak
Lycaenidae	*Callophrys niphon*	Eastern pine elfin
Lycaenidae	*Celastrina l. ladon "neglecta"*	Summer azure
Lycaenidae	*Celastrina l. ladon "violocea"*	Spring azure
Lycaenidae	*Everes comyntas*	Eastern tailed blue
Lycaenidae	*Feniseca tarquinius*	Harvester
Lycaenidae	*Lycaena Phlaeas*	American copper
Lycaenidae	*Satyrium calanus*	Banded hairstreak
Lycaenidae	*Satyrium titus*	Coral hairstreak
Lycaenidae	*Strymon melinus humuli*	Gray hairstreak
Noctuidae	*Abargrotis alternata*	Greater red dart
Noctuidae	*Acronicta americana*	American dagger moth
Noctuidae	*Acronicta inclara*	Unclear dagger moth
Noctuidae	*Acronicta lithospila*	Streaked Dagger Moth
Noctuidae	*Acronicta sp.*	Dagger moth
Noctuidae	*Agrostis venerabilis*	Venerable Dart
Noctuidae	*Anagrapha falcifera*	Celery looper moth
Noctuidae	*Caenurgina crassiuscula*	Clover Looper Moth
Noctuidae	*Caenurgina erechtea*	Forage looper moth
Noctuidae	*Cerma cerintha*	Tufted bird-dropping moth
Noctuidae	*Euparthenos nubilis*	Locust Underwing
Noctuidae	*Heliothis zea*	Corn Earworm Moth
Noctuidae	*Lacinipolia renigera*	Bristly Cutworm Moth
Noctuidae	*Lithacodia carneola*	Pink-barred lithacodia
Noctuidae	*Mocis texana*	Texas mocis
Noctuidae	*Orthodes cynica*	Cynical Quaker
Noctuidae	*Spodoptera ornithogalli*	Yellow-striped Armyworm Moth

Noctuidae	*Spodpotera frugiperda*	Fall Armyworm Moth
Noctuidae	*Xestia badinodis*	Pale-banded Dart
Noctuidae	*Xestia bicarnea*	Pink-spotted Dart
Noctuidae	*Xestia dolosa*	Greater black-letter dart
Noctuidae	*Zale galbanata*	Maple Zale
Noctuidae	*Zale metatoides*	Washed-out zale
Noctuidae	*Zanclognatha sp.*	
Notodonitidae	*Nadata gibbosa*	White-dotted prominent
Notodonitidae	*Symmerista albifrons*	White-headed prominent
Nymphalidae	*Asterocampa c. celtis*	Hackberry emperor
Nymphalidae	*Asterocampa c. clyton*	Tawny emperor
Nymphalidae	*Cercyonis pegala*	Common wood nymph
Nymphalidae	*Chlosyne nycteis*	Silvery checkerspot
Nymphalidae	*Danaus plexippus*	Monarch
Nymphalidae	*Enodia anthedon*	Northern pearly eye
Nymphalidae	*Euptoieta claudia*	Variegated fritillary
Nymphalidae	*Junonia coenia*	Common buckeye
Nymphalidae	*Libytheana carinenta*	American snout
Nymphalidae	*Limenitis arthemis astyanax*	Red-spotted purple
Nymphalidae	*Megisto cymela*	Little wood satyr
Nymphalidae	*Nymphalis antiopa*	Mourning cloak
Nymphalidae	*Phyciodes tharos*	Pearl crescent
Nymphalidae	*Polygonia comma*	Eastern comma
Nymphalidae	*Polygonia interrogationis*	Question mark
Nymphalidae	*Speyeria aphrodite*	Aphrodite fritillary
Nymphalidae	*Speyeria cybele*	Great spangled fritillary
Nymphalidae	*Speyeria idalia*	Regal fritillary
Nymphalidae	*Vanessa virginiensis*	American lady
Nymphalidae	*Vanessa atalanta*	Red admiral
Papilionidae	*Battus philenor*	Pipevine swallowtail
Papilionidae	*Papilio glaucus*	Eastern tiger swallowtail
Papilionidae	*Papilio polyxenes*	Black swallowtail
Papilionidae	*Papilio troilus*	Spicebush swallowtail
Pieridae	*Anthocharis midea*	Falcate orangetip
Pieridae	*Colias eurytheme*	Orange sulfer
Pieridae	*Colias philodice*	Clouded sulfer
Pieridae	*Eurema lisa*	Little yellow
Pieridae	*Eurema nicippi*	Sleepy orange
Pieridae	*Phoebis sennae*	Cloudless sulpher
Pieridae	*Pieris rapae*	Cabage white
Pyralidae	*Desmia funeralis*	Grape Leaffolder Moth
Pyralidae	*Desmia maculalis*	
Saturniidae	*Anisota stigma*	Spiny oakworm moth
Saturniidae	*Drycampa rubicunda*	Rosy Maple Moth
Saturniidae	*Dryocampa rubicunda*	Rosy maple moth
Sphingidae	*Ceratomia catalpae*	Catalpa Sphinx
Tortricidae	*sp.*	Tortricid moth

Yponomeutidae	*Atteva punctella*	Ailanthus Webworm Moth

Class: Insecta
Order: Neuroptera

Family	Scientific Name	Common Name
Chrysopidae	*sp.*	Green lacewing
Corydalidae	*Chauliodes sp.*	Dobsonfly
Corydalidae	*Neohermis sp.*	Dobsonfly
Corydalidae	*Nigronia sp.*	Dobsonfly
Corydalidae	*sp.*	Dobsonfly
Hemerobiidae	*sp.*	Lacewing
Sialidae	*sp.*	Alderfly

Class: Insecta
Order: Odonata

Family	Scientific Name	Common Name
Aeshnidae	*Aeshna umbrosa*	Shadow Darner
Aeshnidae	*Boyeria vinosa*	Fawn Darner
Coenagrionidae	*Argia moesta*	Powdered Dancer
Gomphidae	*Dromogomphus spinosus*	Black-shouldered Spinyleg
Gomphidae	*Ophiogomphus rupinsulenis*	Rusty Snaketail
Gomphidae	*Stylurus spiniceps*	Arrow Clubtail
Lestidae	*Lestes rectangularis*	Slender Spreadwing
Libellulidae	*Erythemis simplicicollis*	Eastern Pondhawk
Libellulidae	*Libellula pulchella*	Twelve-spotted Skimmer
Libellulidae	*Libellula semifasciata*	Painted Skimmer
Libellulidae	*Pachydiplax longipennis*	Blue Dasher
Libellulidae	*Sumpetrum vicinum*	Yellow-legged Meadowhawk
Macromiidae	*Macromia illinoisensis illinoisensis*	Illinois River Cruiser

Class: Insecta
Order: Orthoptera

Family	Scientific Name	Common Name
Blatellidae	*Parcoblatta sp.*	Cockroach
Gryllacrididae	*sp.*	Camel cricket
Mantidae	*sp.*	Mantis

Class: Insecta
Order: Plecoptera

Specimen not identified beyond order.

Class: Insecta
Order: Pscoptera

Specimen not identified beyond order.

Class: Insecta
Order: Thysanoptera

Specimen not identified beyond order.

Class: Insecta
Order: Thysanura

Family	Scientific Name	Common Name
Machilidae	*Machilis sp.*	Bristletail

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Hydropsychidae	*Cheumatopsyche sp.*	Caddisfly
Hydropsychidae	*Hydropsyche sp.*	Caddisfly
Hydropsychidae	*Potomyia sp.*	Caddisfly

Class: Insecta
Order: Trichoptera

Family	Scientific Name	Common Name
Philopotamidae	*Chimarra sp.*	Caddisfly
Psychomyiida	Lype diversa	Caddisfly

Class: Malacostraca
Order: Decapoda

Family	Species	Common Name
Cambaridae	*Cambarus sciotensis*	
Cambaridae	*Orconectes chasmodactylus*	New River cray fish
Cambaridae	*Orconectes virilis*	virile crayfish

Class: Malacostraca
Order: Isopoda

Family	Scientific Name	Common Name
Ligiidae	*Ligidium sp.*	Pill bug
Oniscidae	*Cylisticus sp.*	Pill bug
Oniscidae	*Trachelipus sp.*	Pill bug
Trichoniscidae	*Hyloniscus sp.*	Pill bug

Source: 1998 Biological Survey of RFAAP Including Threatened, Endangered, and Species of Concern.
(Virginia Department of Game and Inland Fisheries)

FISH

Family	Species	Common Name
Catastomidae	*Catostomus commersoni*	white sucker
Catastomidae	*Hypentelium nigricans*	northern hogsucker
Centrarchidae	*Ambloplites rupestris*	rock bass
Centrarchidae	*Lepomis auritus*	redbreast sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill
Centrarchidae	*Micropterus dolomieui*	smallmouth bass
Centrarchidae	*Micropterus punctulatus*	spotted bass
Centrarchidae	*Micropterus salmoides*	largemouth bass
Cottidae	*Cottus bairdi*	mottled sculpin
Cyprinidae	*Campostoma anomalum*	central stoneroller
Cyprinidae	*Climostomus funduloides*	rosyside dace
Cyprinidae	*Cyprinella galactura*	whitetail shiner
Cyprinidae	*Cyprinus carpio*	common carp
Cyprinidae	*Luxilus albeolus*	white shiner
Cyprinidae	*Nocomis leptocephalus*	bluehead chub
Cyprinidae	*Nocomis micropogon*	river chub
Cyprinidae	*Nocomis platyrhychus*	bigmouth chub
Cyprinidae	*Notropis hudsonius*	spottail shiner
Cyprinidae	*Notropis telescopus*	telescope shiner
Cyprinidae	*Phoxinus oreas*	mountain redbelly dace
Cyprinidae	*Pimephales notatus*	bluntnose minnow
Cyprinidae	*Rhinichthys atratulus*	blacknose dace
Esocidae	*Esox masquinongy*	muskellunge
Ictaluridae	*Noturus insignis*	margined madtom
Ictaluridae	*Pylodictis olivaris*	flathead catfish
Percichthyidae	*Morone sp.*	bass
Percidae	*Etheostoma blennioides*	greenside darter
Percidae	*Etheostoma flabellare*	fantail darter
Percidae	*Perca flavescens*	yellow perch
Percidae	*Percina caprodes*	logperch
Percidae	*Percina gymnocephala*	Appalachia darter
Percidae	*Percina roanoka*	Roanoke darter

REPTILES AND AMPHIBIANS

Family	Scientific Name	Common Name
Ambystomatidae	*Ambystoma jeffersonianum*	Jefferson salamander
Ambystomatidae	*Ambystoma maculatum*	spotted salamander
Bufonidae	*Bufo americanus*	American toad
Bufonidae	*Bufo woodhousii*	Fowler's toad
Chelydridae	*Chelydra serpentina*	snapping turtle
Colubridae	*Carphophis amoenus*	eastern worm snake
Colubridae	*Diadophis punctatus*	ringneck snake
Colubridae	*Elaphe obsoleta*	black rat snake

Colubridae	*Nerodia sipedon*	northern water snake
Colubridae	*Regina septemvittata*	queen snake
Colubridae	*Thamnophis sirtalis*	eastern garter snake
Emydidae	*Chrysemys picta*	eastern painted turtle
Hylidae	*Hyla versicolor*	gray treefrog
Plethodontidae	*Desmognathus fuscus*	northern dusky salamander
Plethodontidae	*Desmognathus quadramaculatus*	blackbelly salamander
Plethodontidae	*Eurycea cirrigera*	southern two-lined salamander
Plethodontidae	*Plethodon cinereus*	redback salamander
Plethodontidae	*Plethodon glutinosus*	slimy salamander
Plethodontidae	*Plethodon wehrlei*	Wehrle's salamander
Ranidae	*Rana sylvatica*	wood frog
Salamandridae	*Notophthalmus viridescens*	red-spotted newt

BIRDS

Family	Scientific Name	Common Name
Accipitridae	*Accipiter striatus*	sharp-shinned hawk
Accipitridae	*Buteo jamaicensis*	red-tailed hawk
Accipitridae	*Circus cyaneus*	northern harrier
Accipitridae	*Falco sparverius*	American kestrel
Alcedinidae	*Ceryle alcyon*	belted kingfisher
Anatidae	*Aix sponsa*	wood duck
Anatidae	*Anas americana*	American wigeon
Anatidae	*Anas platyrhynchos*	mallard duck
Anatidae	*Anas rubripes*	American black duck
Anatidae	*Anas strepera*	gadwall
Anatidae	*Branta canadensis*	Canada goose
Anatidae	*Bucephala albeola*	bufflehead
Anatidae	*Lophodytes cucullatus*	hoodeed merganser
Apodidae	*Chaetura pelagica*	chimney swift
Ardeidae	*Ardea herodias*	great blue heron
Ardeidae	*Butorides striatus*	green heron
Ardeidae	*Casmerodius albus*	great egret
Ardeidae	*Nycticorax nycticorax*	black-crowned night-heron
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing
Cathartidae	*Cathartes aura*	turkey vulture
Cathartidae	*Coragyps atratus*	black vulture
Certhiidae	*Certhia americana*	brown creeper
Charadriidae	*Charadrius vociferus*	killdeer
Columbidae	*Columba livia*	rock dove
Columbidae	*Zenaida macroura*	mourning dove
Corvidae	*Corvus brachyrhynchos*	American crow
Corvidae	*Corvus corax*	common raven
Corvidae	*Cyanocitta cristata*	blue jay
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo
Cuculidae	*Coccyzus erythropthalmus*	black-billed cuckoo

Emberizidae	*Agelaius phoeniceus*	red-winged blackbird
Emberizidae	*Cardinalis cardinalis*	northern cardinal
Emberizidae	*Dendroica coronata*	yellow-rumped warbler
Emberizidae	*Dendroica donimica*	yellow-throated warbler
Emberizidae	*Dendroica magnolia*	magnolia warbler
Emberizidae	*Dendroica palmarum*	palm warbler
Emberizidae	*Dendroica pensylvanica*	cheastnut-sided warbler
Emberizidae	*Dendroica petechia*	yellow warbler
Emberizidae	*Dendroica pinus*	pine warbler
Emberizidae	*Dendroica striata*	blackpoll warbler
Emberizidae	*Dendroica virens*	black-throated green warbler
Emberizidae	*Geothlypis trichas*	common yellowthroat
Emberizidae	*Helmitheros vermivorus*	worm-eating warbler
Emberizidae	*Icterus galbula*	northern oriole
Emberizidae	*Icterus spurius*	orchard oriole
Emberizidae	*Junco hyemalis*	northern junco
Emberizidae	*Melospiza georgiana*	swamp sparrow
Emberizidae	*Melospiza melodia*	song sparrow
Emberizidae	*Mniotilta varia*	black-and-white warbler
Emberizidae	*Molothrus ater*	brown-headed cowbird
Emberizidae	*Oporornis formosus*	kentucky warbler
Emberizidae	*Parula americana*	northern parula
Emberizidae	*Passer domesticus*	house sparrow
Emberizidae	*Passerina cyanea*	indigo bunting
Emberizidae	*Pheucticus ludovicianus*	rose-breasted grosbeak
Emberizidae	*Pipilo erythrophthalmus*	eastern towhee
Emberizidae	*Piranga olivacea*	scarlet tanager
Emberizidae	*Pooecetes gramineus*	vesper sparrow
Emberizidae	*Quiscalus quiscula*	common grackle
Emberizidae	*Seiurus aurocapillus*	ovenbird
Emberizidae	*Seiurus motacilla*	Louisana waterthrush
Emberizidae	*Seiurus noveboracensis*	northern waterthrush
Emberizidae	*Setophaga ruticilla*	American redstart
Emberizidae	*Spizella passerina*	chipping sparrow
Emberizidae	*Spizella pusilla*	field sparrow
Emberizidae	*Sturnella magna*	eastern meadowlark
Emberizidae	*Zonotrichia albicollis*	white-throated sparrow
Fringillidae	*Carduelis tristis*	American goldfinch
Fringillidae	*Carpodacus mexicanus*	house finch
Fringillidae	*Carpodacus purpureus*	purple finch
Hirundinidae	*Hirundo rustica*	barn swallow
Hirundinidae	*Progne subis*	purple martin
Hirundinidae	*Riparia riparia*	bank swallow
Hirundinidae	*Stelgidopteryx serripennis*	rough-winged swallow
Hirundinidae	*Tachycineta bicolor*	tree swallow
Laridae	*Larus delawarensis*	ring-billed gull
Mimidae	*Dumetella carolinensis*	gray catbird

Mimidae	*Mimus polyglottos*	northern mockingbird
Muscicapidae	*Catharus guttatus*	hermit thrush
Muscicapidae	*Hylocichla mustelina*	wood thrush
Muscicapidae	*Polioptila caerulea*	blue-gray gnatcatcher
Muscicapidae	*Regulus satrapa*	golden-crowned kinglet
Muscicapidae	*Sialia sialis*	eastern bluebird
Muscicapidae	*Turdus migratorius*	American robin
Paridae	*Parus bicolor*	tufted titmouse
Paridae	*Parus carolinensis*	carolina chickadee
Phalacrocoracidae	*Phalacrocorax auritus*	double-crested cormorant
Phasianidae	*Bonasa umbellus*	ruffed grouse
Phasianidae	*Meleagris gallopavo*	wild turkey
Picidae	*Colaptes auratus*	northern flicker
Picidae	*Dryocopus pileatus*	pileated woodpecker
Picidae	*Melanerpes carolinus*	red-bellied woodpecker
Picidae	*Picoides pubescens*	downy woodpecker
Picidae	*Picoides villosus*	hairy woodpecker
Picidae	*Sphyrapicus varius*	yellow-bellied sapsucker
Podicipedidae	*Podilymbus podiceps*	pied-billed grebe
Rallidae	*Fulica americana*	American coot
Scolopacidae	*Actitis macularia*	spotted sandpiper
Scolopacidae	*Scolopax minor*	American woodcock
Sittidae	*Sitta canadensis*	red-breasted nuthatch
Sittidae	*Sitta carolinensis*	white-breasted nuthatch
Strigidae	*Otus asio*	eastern screech owl
Sturnidae	*Sturnus vulgaris*	European starling
Trochilidae	*Archilochus colubris*	ruby-throated hummingbird
Troglodytidae	*Thryothorus ludovicianus*	carolina wren
Troglodytidae	*Troglodytes aedon*	house wren
Troglodytidae	*Troglodytes troglodytes*	winter wren
Tyrannidae	*Contopus virens*	eastern pewee
Tyrannidae	*Empidonax virescens*	acadian flycatcher
Tyrannidae	*Myiarchus crinitus*	great crested flycatcher
Tyrannidae	*Sayornis phoebe*	eastern phoebe
Tyrannidae	*Sturnella magna*	eastern kingbird
Tyrannidae	*Tyrannus tyrannus*	eastern kingbird
Vireonidae	*Vireo flavifrons*	yellow-throated vireo
Vireonidae	*Vireo gilvus*	warbling vireo
Vireonidae	*Vireo griseus*	white-eyed vireo
Vireonidae	*Vireo olivaceus*	red-eyed vireo

MAMMALS

Family	Scientific Name	Common Name
Cervidae	*Odocoileus virginianus*	white-tailed deer
Diedelphidae	*Didelphis virginiana*	Virginia opossum
Dipodidae	Zapus hudsonius	meadow jumping mouse

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Mephitidae	*Mephitis mephitis*	striped skunk
Muridae	Microtis pennsylvanicus	meadow vole
Muridae	Peromyscus leucopus	white-footed mouse
Procyonidae	*Procyon lotor*	common raccoon
Sciuridae	*Marmota monax*	woodchuck
Sciuridae	*Sciurus carolinensis*	eastern gray squirrel
Sciuridae	*Sciurus niger*	eastern fox squirrel
Sciuridae	*Tamias striatus*	eastern chipmunk
Soricidae	Blarina brevicauda	northern short-tailed shrew
Soricidae	Cryptotis parva	least shrew
Soricidae	Sorex fumeus	smoky shrew
Talpidae	Parascalops breweri	hairy-tailed mole