ARMY'S ENVIRONMENTAL REPORT FOR NRC MATERIALS LICENSE SUB-1435

Depleted Uranium Impact Area
Jefferson Proving Ground, Madison, Indiana

Prepared for:

U.S. Department of Army
1 Rock Island Arsenal
Rock Island, Illinois 61299-5000

and

U.S. Army Corps of Engineers
Louisville District
600 Dr. Martin Luther King, Jr. Place
Louisville, Kentucky 40202-2232

August 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per Liter
µR	MicroRoentgen
µR/hr	MicroRoentgens per Hour
µmhos/cm	Micromhos per Centimeter
ac	Acre
ACHP	Advisory Council on Historic Preservation
ACS	American Community Survey
ADA	Americans with Disabilities Act
AGI	Advanced Geosciences, Inc.
ALARA	As Low As Reasonably Achievable
AMSL	Above Mean Sea Level
ANG	Air National Guard
AQS	Air Quality System
AR	Army Regulation
ARCPACS	American Registry of Certified Professionals in Agronomy, Crops and Soils
ARNG	Army National Guard
ARPA	Archaeological Resources Protection Act
ASTM	American Society for Testing and Materials
ATCAA	Air Traffic Control Association Area
BGS	Below Ground Surface
BLM	Bureau of Land Management
BOCS	Big Oaks Conservation Society
BRAC	Base Realignment and Closure
$CaCO_3$	Calcium Carbonate
CCP	Comprehensive Conservation Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cfs/mi^2	Cubic Feet per Second per Square Mile
CHPPM	(U.S. Army) Center for Health Promotion and Preventive Medicine
Ci/g	Curies per Gram
cm	Centimeter
cm/y	Centimeters per Year
cpm	Counts per Minute
CPSC	Certified Professional Soil Scientist
CRMP	Cultural Resources Management Plan
CSM	Conceptual Site Model
DA	Department of the Army
DCGL	Derived Concentration Guideline Level
DGPS	Differential Global Positioning System
DPT	Direct-Push Technology
DO	Dissolved Oxygen
DODI	U.S. Department of Defense Instruction
DOE	U.S. Department of Energy
DU	Depleted Uranium
EA	Environmental Assessment
EDS	Energy Dispersive Spectrometer
EG&G	EG&G Mound Applied Technologies Corporation

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

Eh	Redox Potential
EI	Electrical Imaging
EM	Environmental Manager
EO	Executive Order
EOD	Explosive Ordnance Disposal
EP	Engineer Pamphlet
ER	Environment Report
ERM	Environmental Radiation Monitoring
ESA	Endangered Species Act
ET	Evapotranspiration
eV	Electron Volt
FMP	Fire Management Plan
FONSI	Finding of No Significant Impact
FSP	Field Sampling Plan
ft	Foot
ft/day	Feet per Day
ft/ft	Feet per Foot
ft/mi	Feet per Mile
ft/sec	Feet per Second
ft^2	Square Feet
FTP	Field Technical Procedure
FWS	U.S. Fish and Wildlife Service
g/cm^2-y	Grams per Square Centimeter per Year
g/cm^3	Grams per Cubic Centimeter
$gal/day/ft^2$	Gallons per Day per Square Foot
GIS	Geographic Information System
GM	Geiger-Müeller
gpm	Gallons per Minute
GPS	Global Positioning System
ICDD	International Centre for Diffraction Data
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrometry
ICRMP	Integrated Cultural Resources Management Plan
ID	Identification
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
in	Inch
in/y	Inches per Year
INANG	Indiana Air National Guard
JPG	Jefferson Proving Ground
K_d	Distribution Coefficient
keV	Kilo-Electron Volt
kg	Kilogram
km	Kilometer
km^2	Square Kilometer
L/min	Liters per Minute
LA/RC	Legal Agreement and Restrictive Covenant
LLRW	Low-Level Radiological Waste
LRSO	Licensed Radiation Safety Officer
LTC	Long-Term Control

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

LTP	License Termination Plan
LTR	License Termination Rule
µg/L	Microgram per Liter
µR	MicroRoentgen
µR/hr	MicroRoentgen per Hour
µm	Micrometer
m	Meter
m^2	Square Meter
MBq/g	Megabecquerels per Gram
MCL	Maximum Contaminant Level
MCLinc	Materials and Chemistry Laboratory, Inc.
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
mi	Mile
mi^2	Square Mile
mL/g	Milliliters per Gram
mm	Millimeter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
mph	Miles per Hour
mrem	Millirem
mrem/y	Millirems per Year
MRR	Madison Railroad
msl	Mean Sea Level
mSv	MilliSievert
MWH	Montgomery Watson Harza
mSv/y	MilliSieverts per Year
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NAD-83	1983 North American Datum
NAGPRA	Native American Graves Protection and Repatriation Act
NaI	Sodium Iodide
NARA	U.S. National Archives and Records Administration
NCDC	National Climatic Data Center
NCSHPO	National Conference of State Historic Preservation Officers
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NMSS	Office of Nuclear Material Safety and Safeguards
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NUREG	U.S. Nuclear Regulatory Commission Regulation
NTU	Nephelometric Turbidity Unit
NWR	National Wildlife Refuge
OB/OD	Open Burning/Open Detonation
OSD	Official Soil Description

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

OSHA	Occupational Safety and Health Administration
ORP	Oxidation-Reduction Potential
Pa	Protactinium
PAC	Purdue Agricultural Center
PC	Personal Computer
pCi/g	Picocuries per Gram
pCi/L	Picocuries per Liter
PCZ	Primary Contamination Zone
PGM	Precision-Guided Munitions
PM_{10}	Particulate Matter Smaller than 10 Micrometers
$PM_{2.5}$	Particulate Matter Smaller than 2.5 Micrometers
Po-234m	Polonium-234m
Pu-239	Plutonium-239
Pu-240	Plutonium-240
QA	Quality Assurance
QC	Quality Control
R^2	Coefficient of Determination
RACER™	Remedial Action Cost Engineering and Requirements
RAI	Request for Additional Information
RCRA	Resource Conservation and Recovery Act
redox	Oxidation-Reduction
RESRAD	Residual Radiation
RI	Remedial Investigation
ROD	Record of Decision
RQD	Rock Quality Designation
RSO	Radiation Safety Officer
RSP	Radiation Safety Plan
SAIC	Science Applications International Corporation
SCZ	Secondary Contamination Zone
SDWA	Safe Drinking Water Act
SDZ	Surface Danger Zone
SE	Sequential Extraction
SEG	Scientific Ecology Group
SEM	Scanning Electron Microscope
SEM-EDS	Scanning Electron Microscopy with Energy Dispersive Spectrometry
SHPO	State Historic Preservation Office (or Officer)
SOP	Standard Operating Procedure
SRP	Standard Review Plan
S.U.	Standard Unit
SSURGO	Soil Survey Geographic
SVS	Soil Verification Study
Tc-99	Technetium-99
TECOM	U.S. Army Test and Evaluation Command
TEDE	Total Effective Dose Equivalent
Th-234	Thorium-234
TOC	Total Organic Carbon
U	Uranium
U.S.C.	United States Code
U^{+4}	Tetravalent Uranium

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

U^{+6}	Hexavalent Uranium
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
UCL-95	95 Percent Upper Confidence Limit on the Arithmetic Mean
UO_2	Uranium Dioxide
UO_3	Uranium Trioxide
UO_4	Uranium Peroxide
$UO_3 \cdot 2H_2O$	Dihydrated Uranium Trioxide
$UO_4 \cdot 4H_2O$	Hydrated Uranyl Peroxide
USAF	U.S. Air Force
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
XPS	X-ray Photoelectron Spectrometer
XRD	X-ray Diffraction
YPG	Yuma Proving Ground

1. INTRODUCTION OF THE ENVIRONMENTAL REPORT

This Environmental Report was prepared in support of the Army's Proposed Action to terminate its U.S. Nuclear Regulatory Commission (NRC) Materials License for the Jefferson Proving Ground (JPG) located in Madison, Indiana (Figure 1-1). Materials License SUB-1435, Docket Number 40-08838, Amendment No. 17 (Appendix A) allows for the possession only of up to 176,370 pounds (lb) (80,000 [kilograms] kg) of depleted uranium (DU) metal, alloy, and/or other forms in the DU Impact Area (Figure 1-2).

This Environmental Report fulfills requirements specified in Title 10, Code of Federal Regulations (CFR) Parts 51.45 (Environmental Report) and 51.60 (Environmental Report-Materials Licenses). The Decommissioning Plan (U.S. Army 2013a) includes additional information related to the Army's Proposed Action to terminate NRC Materials License SUB-1435.

1.1 PURPOSE AND NEED FOR THE PROPOSED ACTION

The active Army mission at JPG ceased on 30 September 1994. At that time, all mission activities at JPG ended and were realigned to Yuma Proving Ground (YPG), Arizona because of the Defense Authorization Amendments and Base Realignment and Closure (BRAC) Act of 1988 (Public Law 100-526). Since mission operations at JPG ended, the Army has not fired any DU penetrators and, therefore, is proposing to terminate NRC Materials License SUB-1435 for the DU Impact Area to fulfill requirements in 10 CFR Subpart E (Radiological Criteria for License Termination).

1.2 THE PROPOSED ACTION

The Proposed Action is license termination under restricted conditions in accordance with 10 CFR 20.1403 (Criteria for License Termination Under Restricted Conditions). More specifically, the NRC Materials License SUB-1435 would be terminated with durable institutional controls for the DU Impact Area. These controls are reliable and sustainable for the first 1,000 years after decommissioning using physical, administrative, and legal mechanisms. These controls satisfy recommendations for institutional controls in U.S. Nuclear Regulatory Commission Regulation (NUREG) 1757 (NRC 2006a) as follows:

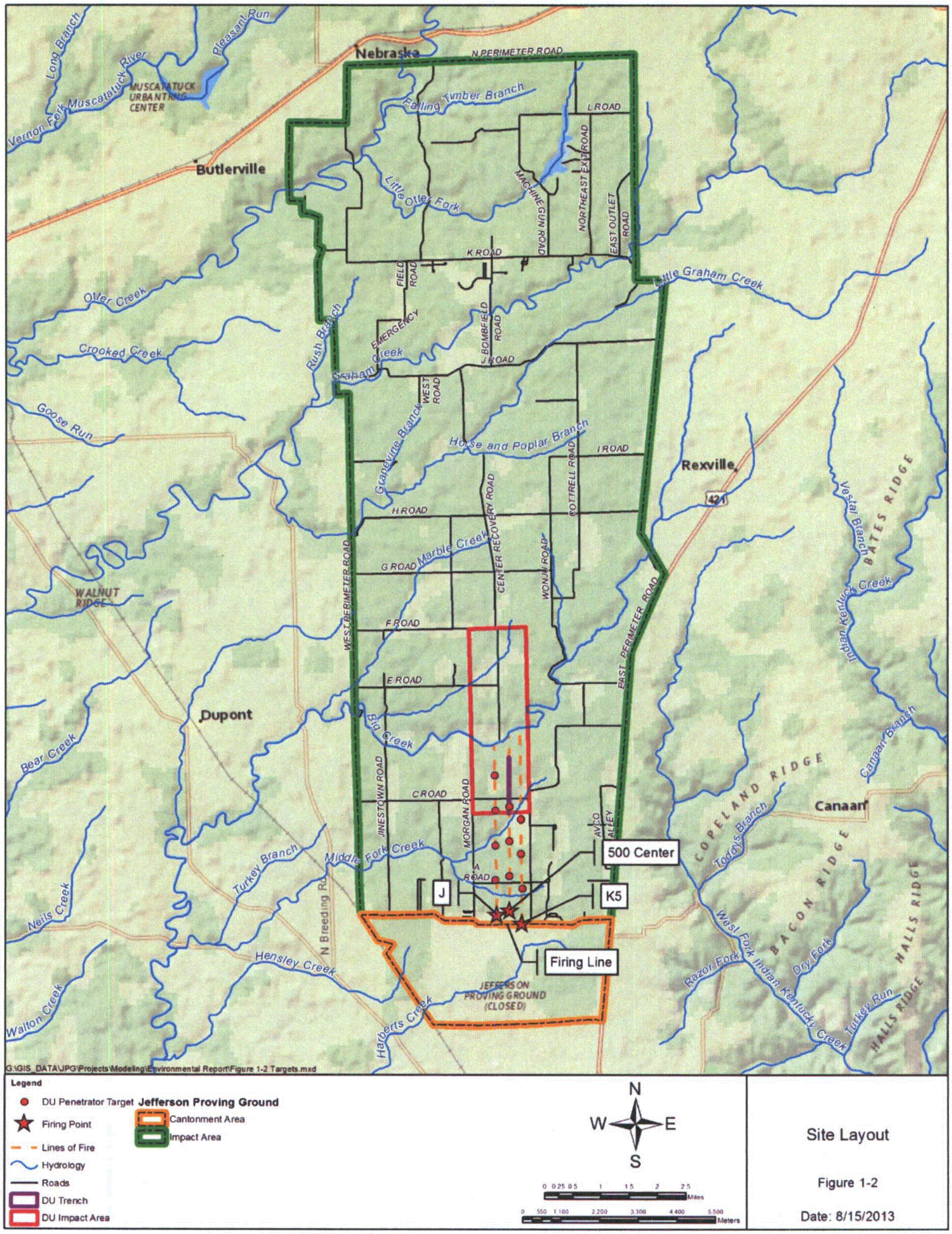
- The residual dose analysis conducted using Residual Radiation (RESRAD)-OFFSITE Version 2.6 (Yu et al. 2010) simulated potential exposures to receptors at sites located both inside and outside the area of institutional control. Under restricted conditions, the institutional controls limit the calculated dose to 0.25 milliSieverts per year (mSv/y) (25 millirems per year [mrem/y]). The calculated dose does not exceed 1 mSv/y (100 mrem/y) if the institutional controls are assumed to fail. Section 4 of the Decommissioning Plan (U.S. Army 2013a) provides additional details about the residual dose analysis.

  Further reductions in residual radioactivity are likely to cause net environmental harm. The estimated 85 high-explosive unexploded ordnance (UXO) rounds per acre present throughout the DU Impact Area (Final Environmental Impact Statement 1995, Figure 4-12, page 4-42 [U.S. Army 1995a]) must be removed prior to removal of DU penetrators or DU-contaminated soil (USACE 2004). For safety reasons, the UXO removal process would include the in-place detonation of a large number of high-explosive UXO items that could irreparably damage the habitat of the Indiana Bat, a federally listed endangered species known to exist within the Big Oaks National Wildlife Refuge (NWR) in the DU Impact Area. Furthermore, the explosions resulting from the in-place detonations of UXO items would scatter DU penetrators and contaminated soil beyond current areas. These explosions also could entrain DU corrosion products and soil-bound DU into the atmosphere, contributing to the inhalation pathway and residual radiation dose beyond those evaluated in the residual dose analysis. Section 4 provides additional details about the potential environmental impacts for the No Action alternative and Proposed Action.

Regional Location

Figure 1-1

Date: 7/31/2013



Site Layout

Figure 1-2

Date: 8/15/2013

- Further reductions in residual radioactivity are economically not feasible. The residual DU activity is as low as reasonably achievable (ALARA) because of the extraordinarily high costs of UXO and DU detection, removal, and disposal and the small benefit that would result from the cleanup of an approximately 2,080-acre (ac) (8.4-[square kilometer] km^2) area inside the 50,950-ac (206-km^2) portion of JPG where UXO is present. Section 7 provides additional details about the costs and benefits for the Proposed Action and for each alternative.

- The Army has implemented and will continue to maintain all of the controls needed to legally enforce access controls and land use restrictions (i.e., legally enforceable institutional controls) to ensure that doses to the average members of the critical group are less than 0.25 mSv/y (25 mrem/y). The Army is an enduring public institution capable of maintaining durable institutional controls that are both reliable and sustainable for the first 1,000 years after license termination. Consistent with the JPG "Disposal and Reuse Environmental Statement Record of Decision" (ROD) (U.S. Army 1996), the Army will retain title to the DU Impact Area property and the surrounding area "in caretaker status until transfer by encumbered title is feasible." "Renewable leases and licenses will be granted, where appropriate, to permit temporary use of real property at JPG prior to its disposal. These will ensure that JPG is maintained within acceptable standards while being readied for transfer to future users" (U.S. Army 1996). At the present time, the Army has established a Memorandum of Agreement (MOA) with the U.S. Fish and Wildlife Service (FWS) for establishment and management of the Big Oaks NWR (approximately 51,000 ac [206 km^2]) and with the U.S. Air Force (USAF) for use of designated portions of JPG as an air to ground bombing training range (1,038 ac [4.2 km^2]) for the Indiana Air National Guard (INANG). This MOA provides that the agreement "shall remain in effect for 25 (twenty-five) years" and "may be renewed for additional 10 (ten) year periods upon mutual agreement" (U.S. Army 2000a). The MOA, page 5, section III.4 also states "The Army will not transfer fee title or other property interests in the Firing Range without consulting with the FWS and Air Force. If in the future the Firing Range is determined suitable for transfer, the Army shall, to the extent legally authorized, provide the FWS and Air Force the right of first refusal on their respective property interests before conveying any property interests. If the Air Force no longer requires use of the Bombing Range and the property is no longer needed for other military purposes, the Army will offer the FWS a real estate permit for the Bombing Range subject to the same terms of this agreement or any other mutually agreeable terms." The MOA is included in the Decommissioning Plan (U.S. Army 2013a). The Army will monitor these agencies for compliance with the terms of the MOA and associated permits. The institutional controls are discussed in further detail in Section 2.1.2.

- The Army has committed to request the necessary annual funding (Financial Assurance) for the implementation and maintenance of institutional controls necessary to support license termination under restricted conditions. Section 12 (Financial Assurance) of the Decommissioning Plan (U.S. Army 2013a) provides the Army's plan to ensure funding is available to support implementation of institutional controls.

- The Army sought public input in accordance with requirements specified in 10 CFR 20.1403(d) for the Army's intent to decommission Materials License SUB-1435 by restricting use of the site. The Army held meetings on 28, 29, and 30 October 2008 in Madison, Versailles, and North Vernon, respectively, and repeated the meetings on 23, 24, and 25 June 2009 in North Vernon, Versailles, and Madison, respectively. Additional details about public input are provided in Section 13.4 of the Decommissioning Plan (U.S. Army 2013a).

1.3 APPLICABLE REGULATORY REQUIREMENTS, PERMITS, AND REQUIRED CONSULTATIONS

This section identifies requirements, agreements, consultations, and permits relating to the management of JPG, including the DU Impact Area. Table 1-1 summarizes the consultations completed or planned in support of installation operations and BRAC closure.

Table 1-1. Consultations and Agreements Completed at JPG to Support Operations, BRAC Closure, and NRC License Termination Jefferson Proving Ground, Madison, Indiana

Consultation	Applicable Law or Regulation	Activity	Status	Reference
Retrocession of Authority	• U.S. Code, Section 2683(a) • Indiana Code Annotated Sections	Retrocession of exclusive jurisdiction to concurrent jurisdiction	Complete	U.S. Army 1995b
Cultural Resources Management Plan	• NHPA of 1966 • EO 11593 • ADA of 1992 • ARPA 1979 • NAGPRA of 1990 • AR 200-4 and 420-40 • MOA between DA, ACHP, and Indiana SHPO • MOA between Army, ACHP, and NCSHPO	Identification, evaluation, and management of historic properties	Complete	Geo-Marine 1996
Fish and Wildlife Management Plan	• Fish and Wildlife Conservation Act of 1958 • ESA of 1973 • Migratory Bird Treaty Act of 1918	Development of plan to manage fish and wildlife resources	Complete	FWS 1994
National Wildlife Refuge	• National Wildlife Refuge Administration Act of 1966 • MOA for INANG's Jefferson Range	Establishment of NWR	Complete	U.S. Army 2000a
Bombing Range	• MOA for INANG's Jefferson Range • Air Force Instruction 13-212, Test and Training Ranges	Continued use of INANG's Jefferson Range	Complete	U.S. Army 2000a
Endangered Species Act	• Section 7 of ESA (16 U.S.C. 1531 et seq.)	Informal consultation on institutional controls planned for restricted release license termination	Complete	Personal Communication 2013a

ACHP = Advisory Council on Historic Preservation
ADA = Americans with Disabilities Act
AR = Army Regulation
ARPA = Archaeological Resources Protection Act
BRAC = Base Realignment and Closure
DA = Department of the Army
EO = Executive Order
ESA = Endangered Species Act
FWS = U.S. Fish and Wildlife Service
INANG = Indiana Air National Guard
MOA = Memorandum of Agreement
NAGPRA = Native American Graves Protection and Repatriation Act
NCSHPO = National Conference of State Historic Preservation Officers
NHPA = National Historic Preservation Act
NRC = U.S. Nuclear Regulatory Commission
NWR = National Wildlife Refuge
SHPO = State Historic Preservation Officer
U.S.C. United States Code

1.3.1 Memorandum of Agreement

A MOA between the Army, USAF, and FWS, signed in May 2000, establishes a framework to authorize the future use of the former firing range by FWS and INANG through USAF and assigns responsibilities for the management of the area of JPG north of the firing line (U.S. Army 2000a). These responsibilities include shared infrastructure management activities, including maintaining buildings, roads, fencing, and signs (see Enclosure 5 of the MOA). The MOA granted real estate permits to both organizations, which remain in effect for 25 years (i.e., expires in June 2025) and may be renewed for additional 10-year periods upon mutual agreement of all parties. Under the MOA and consistent with the JPG ROD (U.S. Army 1996a), the Army retains the authority, responsibility, and liability for contamination (including UXO and DU) resulting from past Army activities. The Army is also authorized to conduct specific activities such as environmental remediation and property administration (e.g., site inspections). The Army is required to consult with FWS and USAF prior to transferring fee title or property interests in the former firing range.

FWS is responsible for all natural resource management decisions on the Big Oaks NWR. FWS is responsible for providing UXO, DU, and environmental contamination safety/awareness training to all personnel and visitors to the publicly accessible portions of the Big Oaks NWR and maintaining infrastructure elements not maintained by INANG on behalf of USAF. Since the Big Oaks NWR includes the DU Impact Area (not publicly accessible), management of the Big Oaks NWR will be subject to the requirements in the Decommissioning Plan as approved by NRC.

INANG operates the Jefferson Range Operations Center for USAF within a demarcated area north of the firing line. The Jefferson Range consists of 983 ac (4.0 km^2) used as the primary training range, a 50-ac (0.2-km^2) Precision-Guided Munitions (PGM) Target Secondary Range, and the Old Timbers Lodge (a historic building) and the surrounding 5 ac (0.020 km^2). All ground access to the range is through the Big Oaks NWR. Please note that INANG, through a Memorandum of Understanding (MOU), has sublet the management, use, and protection of Old Timbers Lodge and its surrounding 5 ac (0.020 km^2) to the Big Oaks Conservation Society (BOCS). Because Old Timbers Lodge is approximately 6.5 miles (mi) north of the northernmost boundary of the DU Impact Area and can be accessed via roads that do not cross the DU Impact Area, the DU exposure potential to BOCS members is severely limited. INANG also is responsible for the maintenance of four historic stone arch bridges, one historic schoolhouse, and the boundary/perimeter fence, as well as several roads including the east and west perimeter roads and those roads that lead to the primary range and secondary range. Please note that INANG, through a Memorandum of Understanding (MOU), has sublet the management, use, and protection of Old Timbers Lodge and its surrounding 5 acres to the Big Oaks Conservation Society (BOCS). Because Old Timbers Lodge is approximately 6.5 miles north of the northernmost boundary of the DU Impact Area and can be accessed via roads that do not cross the DU Impact Area, the DU exposure potential to BOCS members is severely limited.

1.3.2 Section 7 Consultation

As part of the requirements under 10 CFR 20.1403, the Army is required to identify any institutional controls that will be employed as part of the restricted release termination of Materials License SUB-1435. At this point in time, it is anticipated that the Army will propose the following institutional controls (see the Decommissioning Plan [U.S. Army 2013], Section 13.2 for a more detailed discussion of the institutional controls):

- Continued Army ownership of the approximately 50,950 ac (206 km^2) of property at JPG that consists of all of the property north of the firing line
- Continued maintenance of the JPG perimeter chain-link fence
- Continued maintenance of the "No Trespassing" signs on the perimeter chain-link fence
- Continued controlled access to the area north of the firing line at JPG in accordance with the MOA signed by the Army, FWS, and USAF (U.S. Army 2000a)
- Continued restricted access to the DU Impact Area in accordance with the MOA (U.S. Army 2000a).

Under the criteria for restricted release license termination, the Army is providing NRC with sufficient information in this document and the associated Decommissioning Plan (U.S. Army 2013a) that indicates no adverse public exposure from this remaining material within the DU Impact Area. Therefore, the Army is not planning to conduct any cleanup, retrieval, or any other remedial activities regarding the approximate 162,040 lb (73,500 kg) of DU remaining in the DU Impact Area.

FWS was contacted to determine if an informal consultation with FWS under Section 7 of the Endangered Species Act (ESA) for the termination of the Army's Materials License was required due to the presence of the Indiana bat at JPG in relation to the Proposed Action (Personal Communication 2013a). Because the Proposed Action (restricted release license termination) does not include any physical changes to the DU Impact Area and continuing use of the same institutional controls that restrict access north of the firing line and have been followed since the MOA was executed, FWS indicated that an informal consultation is not required. No habitat disturbances from the Proposed Action are expected. As a result, there is a no effect determination by the Army from the Proposed Action on the Indiana bat.

1.3.3 Section 106 Consultation

Cultural resources at JPG are addressed in the 1992 Amended BRAC preliminary assessment between the Army, Advisory Council on Historic Preservation (ACHP), and National Conference of State Historic Preservation Officers (NCSHPO), as well as the MOA between the Army, ACHP, and the Indiana State Historic Preservation Officer (SHPO). All of the National Register of Historic Places (NRHP)-listed or NRHP-eligible properties at JPG should be protected, preserved, or mitigated for loss if primary or secondary impact is unavoidable. The MOA indicates that properties of unknown NRHP eligibility must be considered potentially eligible and should be protected and preserved until the NRHP evaluation process is complete (U.S. Army 2000a). JPG's Cultural Resources Management Plan (CRMP) provides guidelines and procedures to identify, evaluate, and manage historic properties under its jurisdiction (Geo-Marine 1996). The Integrated Cultural Resources Management Plan (ICRMP) serves as the long-term plan to accomplish the missions of the Cultural Resources Program, provides a forum to examine long-term management goals, serves as delegation of authority and responsibility to the INANG Environmental Manager (EM), and certifies the INANG Commander's approval of the plan for JPG/Jefferson Range, Indiana (INANG 2011). Plans and procedures for inventorying cultural resources and assessment of archaeological sites and resources for nomination to the NRHP have been in effect since the mid-1990s. To date, there are two buildings (Old Timbers Lodge and Oakdale Schoolhouse) at JPG listed on the NRHP and four bridges eligible for NRHP listing. None of these structures are located within the DU Impact Area. Section 3.8 includes more information about JPG historic and cultural resources.

1.3.4 Other Permits

Prior to installation closure in 1995, JPG maintained various permits in support of mission operations. These permits included a Resource Conservation and Recovery Act (RCRA) of 1976 permit (Part A, "Interim," and Part B, "Application"), a National Pollutant Discharge Elimination System (NPDES) permit, a Fire Training Permit, an Open Burning/Open Detonation (OB/OD) Permit, and an Air Permit. After installation closure, these permits were transferred or allowed to expire. Currently, there are no Army permits in effect at JPG (MWH 2002).

As a result of the installation's closure, the Federal Government retroceded exclusive jurisdiction over JPG to the State of Indiana under Title 10, United States Code, (U.S.C.) Section 2683(a) to allow concurrent legislative jurisdiction over the JPG land area. This law was not a transfer or disposal of an estate or other interest in land. In effect, the state was granted the authority to enforce its laws for activities occurring on the Federal enclave (U.S. Army 1995b).

The Army was issued and maintains NRC Materials License SUB-1435 pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, and 10 CFR. This license currently authorizes Army possession only of residual DU on JPG. A request to terminate this license under restricted conditions (i.e., the Decommissioning Plan) is scheduled to be submitted to NRC not later than 30 August 2013.

2. ALTERNATIVES

The detailed descriptions of each alternative considered for the Jefferson Proving Ground (JPG) Depleted Uranium (DU) Impact Area are presented in Section 2.1. Section 2.2 discusses alternatives considered but eliminated from detailed analysis. Section 2.3 summarizes the cumulative effects of the Proposed Action. Section 2.4 presents a comparison of the predicted environmental impacts.

2.1 DETAILED DESCRIPTION OF THE ALTERNATIVES

Alternatives that were considered for the DU Impact Area include Alternative 1, U.S. Nuclear Regulatory Commission (NRC) license continuation (No Action) (Section 2.1.1) and Alternative 2, termination of the NRC license for restricted release (Proposed Action) (Section 2.1.2). All alternatives evaluated within this Environmental Report are in accordance with the U.S. Nuclear Regulatory Commission Regulation (NUREG)-1748 guidance. The discussion of the Proposed Action is based on information contained in the Decommissioning Plan (U.S. Army 2013a).

2.1.1 Alternative 1: License Continuation (No Action)

Under the No Action alternative, the Army's NRC Materials License SUB-1435 would remain in effect in accordance with the requirements of Title 10 Code of Federal Regulations (CFR) Part 40. Licensed material would remain in the DU Impact Area; the Environmental Radiation Monitoring (ERM) program for surface soil, sediment, groundwater, and surface water would continue twice per year; and the existing Radiation Safety Plan (U.S. Army 2013b) would continue to be implemented to minimize unauthorized entries into the DU Impact Area.

This alternative does not meet NRC regulatory requirements defined in 10 CFR 40.42(d)(2) for license termination since the principal activities required by the Army's license permanently ceased in 1994 and, therefore, require the Army to terminate their Materials License SUB-1435. Furthermore, this alternative may be inconsistent with the interests of the public, the State of Indiana, or the Army. However, consideration of a No Action alternative is required under the National Environmental Policy Act (NEPA) in order to provide a baseline for comparison with other alternatives.

There should be no major impacts if this alternative were to be selected, since there have been no releases of DU outside the DU Impact Area as evidenced by the semi-annual ERM sampling that commenced in 1983 and there is no hazard or exposure to the public inside the DU Impact Area. Therefore, continuing under the status quo will have no impact on public health and safety or the environment.

2.1.2 Alternative 2: License Termination Under Restricted Conditions (Proposed Action)

Under the Proposed Action, the Army would terminate NRC Materials License SUB-1435, but regardless of whether or not the license is terminated, the Army will continue to maintain institutional control of the area north of the firing line, which includes the DU Impact Area, based on Army ownership of the land and the existence of unexploded ordnance (UXO). Institutional controls that already have been implemented by the Army include physical access restrictions (e.g., perimeter chain-link fence with pad locked chain-link fence gates) to prevent unauthorized entry into the area north of the firing line and including the DU Impact Area. Institutional controls also include legal (e.g., the Army as an agency of the Federal Government and an enduring entity retains property ownership of JPG north of the firing line) and administrative (e.g., restricted and limited public access and hunting prohibitions) controls over the DU Impact Area.

Because of the presence of DU and UXO throughout the licensed area with an estimated 85 high-explosive UXO rounds per acre, this area is not suitable for commercial or residential development.

Institutional controls will continue to be enforced to restrict access to the DU Impact Area. Under the Memorandum of Agreement (MOA) (U.S. Army 2000a), the U.S. Fish and Wildlife Service (FWS) and the U.S. Air Force (USAF) have been assigned infrastructure maintenance responsibilities for the 50,950-acre (ac) (206-[square kilometer] km^2) installation that has become the Big Oaks National Wildlife Refuge (NWR) and the 1,038 ac (4.2 km^2) under the management of the Indiana Air National Guard (INANG) for USAF as an air-to-ground bombing training range.

Consistent with the JPG "Disposal and Reuse Environmental Impact Statement Record of Decision" (ROD) (U.S. Army 1996a), which states that "The Army will maintain and secure the property while in caretaker status," the installation will remain fenced with a 7-foot (ft) (2.13-meter [m]) chain-link fence topped with barbed wire. Approximately 55 miles (mi) (88 [kilometers] km) of fencing surround the installation (INANG 2013). Security warning signs are placed around the property to caution persons not to enter the property. Damaged gates and holes in the fence large enough to permit human access must be repaired within 72 hours of being documented. The impact areas north of the firing line, which contains the DU Impact Area, will remain fenced from the cantonment area (Figure 2-1). Gates through this fenced area will remain locked, and only authorized access is allowed. At each location where a stream crosses the fence line, a steel cable with weighted drainage pipes suspended from the cables has been placed with warning signs attached (Figure 2-2).

Figure 2-1. Fence Separating Cantonment Area From Firing Line/Impact Areas

Figure 2-2. Boundary Fence With Cable/Signs at Stream Crossing

The perimeter fence surrounding the installation will continue to be patrolled and inspected on a regular basis by INANG for USAF under the requirements of the MOA (U.S. Army 2000a). The date of inspection, the name of the inspector, a description, and the location of damage observed will be recorded.

Visitors to the Big Oaks NWR will continue to be required to obtain an annual (or daily) public access permit, attend a safety briefing, and sign an acknowledgment of danger agreement before entering the refuge (this is an annual requirement). Hunting on the refuge will continue to be permitted only in designated areas. The DU Impact Area will remain closed to the public visiting the refuge (FWS 2001a,b).

No environmental monitoring will be conducted under this alternative. ERM activities have been conducted at JPG since 1984 to ensure that DU does not pose a threat to human health and the environment through inadvertent or unanticipated release or migration. The ERM program is described in the standard operating procedure (SOP) (U.S. Army 2000b) developed and issued by the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), predecessor organization to the U.S. Army Public Health Command's Institute for Public Health. This SOP was designed to meet the requirements of applicable Federal and state regulations, including NRC regulations and requirements under radioactive Materials License SUB-1435 (NRC 1985). However, after the termination of radioactive Materials License SUB-1435, environmental monitoring will no longer be required; therefore, ERM is not necessary.

Although the DU Impact Area is a higher risk site due to the presence of radioactive materials with longer radionuclide half-lives (i.e., uranium isotopes with half-lives greater than 100 years), the Army is requesting to not conduct 5-year reviews. NUREG 1757 (NRC 2006a) typically requires licensees to ensure that institutional controls are in place and continue to function and include onsite inspections to verify that prohibited adverse activities are not being conducted. As stated above, the JPG ROD (U.S.

Army 1996) states that "The Army will maintain and secure the property while in caretaker status." To ensure property security, the Army developed the MOA and required INANG for USAF to patrol and inspect the fences on a regular basis due to the potential UXO hazards. These actions will reduce the probability of unauthorized entry into the DU Impact Area. It is notable, however, that the residual radiation dose assuming institutional controls are not in place is well below 1.0 milliSieverts per year (mSv/y) (100 millirems per year [mrem/y]) for the average member of the critical group and only slightly over 0.25 mSv/y (25 mrem/y) (i.e., the maximum dose in the event of loss of institutional controls is 0.263 mSv/y [26.3 mrem/y or only marginally above the unrestricted area dose limit of 0.25 mSv/y (25 mrem/y)]) ([see Appendix C of the Decommissioning Plan (U.S. Army 2013a)]). As such, consistent with NRC guidance, the Army is requesting to not conduct 5-year reviews.

2.1.3 Reasonable Alternatives

No other reasonable alternatives were identified and developed. The Army considered restricted and unrestricted release alternatives. Since the Army is able to implement and maintain durable and legally enforceable institutional controls, an independent third-party arrangement was considered but determined to be unnecessary because of continued property ownership by the Army and the ongoing presence of FWS and INANG for USAF. For the same reasons, the following two options involving NRC support for institutional controls (NRC 2006a) were considered but also determined to be unnecessary: NRC long-term control (LTC) license and NRC legal agreement and restrictive covenant (LA/RC). LTC is a possession-only license used only to satisfy NRC's License Termination Rule (LTR) requirement for legally enforceable and durable institutional controls, which would have required the Army to maintain restrictions on site use; conduct any necessary monitoring, maintenance, and reporting; and be subject to NRC inspections and enforcement to ensure that the Army's controls and other activities are effective (NRC 2006a). LA/RC is a combination of a legal agreement and restrictive covenant that provides a legally enforceable and durable institutional control, with NRC having an oversight role (NRC 2006a). Consistent with NRC guidance contained in NUREG-1757, Volume 1, Revision 2, Appendix M, an LTC license "would be a last resort under the criteria in 10 CFR 20.1403(b)" and should be proposed "only if the licensee cannot otherwise establish acceptable institutional controls or independent third party arrangements." Similarly, an LA/RC may be proposed by a licensee "only if the licensee cannot otherwise establish acceptable institutional controls or independent third party arrangements." Given Federal Government ownership and control of JPG, appropriate institutional controls can be established such that these two alternatives are neither appropriate nor acceptable.

2.2 ALTERNATIVES CONSIDERED BUT ELIMINATED

The alternative of remediating a portion of the 2,080-ac (8.4-km^2) DU Impact Area to remove DU from the surface and subsurface soil was considered but eliminated from detailed analysis for several reasons. The objective of the alternative would be to identify and remove DU-contaminated hotspots to meet the unrestricted release requirements in the DU Impact Area specified in 10 CFR 20.1402. In addition, UXO would be cleared to access the DU penetrators and fragments and DU-contaminated soils to meet requirements in Engineer Pamphlet (EP) 75-1-2 (USACE 2004). The primary factor affecting the decision to eliminate the alternative includes the remaining UXO hazards (estimated at 85 high-explosive UXO rounds per acre [U.S. Army 1995a]) in the areas surrounding the hotspot remediation. In addition, periodic DU penetrator retrieval efforts between 1984 and 1995 already have occurred and were focused on easily retrievable penetrators and fragments in high-probability areas. Other factors, including worker safety; impacts to the environment, including the impact on federally designated endangered species (i.e., Indiana Bat) and its habitat; and the potential cost of the eliminated remedial alternative, are discussed in further detail below.

Further remediation of DU in a portion of the DU Impact Area in order to meet the unrestricted release requirements specified in 10 CFR 20.1402 would not allow for unrestricted use (i.e., commercial or residential development) of the DU Impact Area due to the remaining UXO hazards in areas surrounding the hotspot remediation. Army ownership, land use restrictions, and security measures for the DU Impact Area will remain in place regardless of the radiological status based on the need to mitigate explosive safety hazards associated with UXO.

In addition, UXO remains in areas of the installation surrounding the DU Impact Area. Approximately 1.5 million rounds potentially remain as high-explosive rounds of UXO plus an estimated 3 to 5 million with live detonators, primers, or fuzes within the installation north of the firing line due to Army munitions testing conducted between 1941 and 1994 (SAIC 1997). Prior DU penetrator and fragment retrieval efforts were completed periodically between 1984 and 1995 and focused on easily retrievable DU penetrators and fragments within the line of fire for the 500 Center firing position where fired penetrators had cleared long, narrow paths of vegetation. It is estimated that approximately 220,462 pounds (lb) (100,000 [kilograms] kg) of DU projectiles were fired into the DU Impact Area between 18 March 1984 and 2 May 1994. Although not required by Materials License SUB-1435, but to ensure the Army mass of DU did not exceed license limits, approximately 58,423 lb (26,500 kg) of DU penetrators and fragments were recovered on or near the surface during periodic removals from 1984 to 1995. Approximately 162,040 lb (73,500 kg) of DU remain in the DU Impact Area (Personal Communication 2013b). Interviews with a former Army Radiation Safety Officer (RSO)/Health Physicist for JPG confirmed that the retrieval efforts focused on DU penetrators and fragments located on or near the surface and within the line of fire for the 500 Center firing position where fired penetrators had cleared long, narrow paths of vegetation (Personal Communication 2013c). It is expected that the majority of the remaining DU penetrators and fragments are within the subsurface of these long, narrow paths and at or near ground surface outside the lines of fire.

INANG for USAF is currently using an operational range known as Jefferson Range on a 1,038-ac (4.2-km^2) portion of the Big Oaks NWR (INANG 2013). The Air Force Bombing Range activities involve training munitions (i.e., practice munitions with spotting charges) and laser energy. The 983-ac (4.0-km^2) primary range is located several miles north of the DU Impact Area, but the safety fans for a 50-ac (0.21-km^2) secondary Precision-Guided Munitions (PGM) range, which is located just north of F Road (i.e., northern boundary of the DU Impact Area), extend over a portion of the DU Impact Area.

Considering the prevailing UXO hazards and ongoing training operations, hotspot remediation of DU penetrators and fragments and DU-contaminated soil would have little to no impact on the future use of the DU Impact Area and the installation as a whole. Furthermore, if the removal of UXO and DU penetrators or fragments and DU-contaminated soil were completed, it would require a significant effort that could irreparably damage the habitat of the Big Oaks NWR in the DU Impact Area and scatter DU during munitions destruction activities. Because of the occurrence of UXO in the DU Impact Area, excavation would likely be done remotely to ensure worker safety, thus increasing the time and cost to complete the project. In addition, UXO is buried throughout the DU Impact Area; consequently, a portion of the 2,080 ac (8.4 km^2) of land would have to be excavated, resulting in the destruction of habitat for many species of plants and animals, significant soil erosion, increased runoff, and disturbance of stream sediment. The explosive destruction of UXO identified during excavation as well as the excavation and offsite removal of penetrators and contaminated soil would entrain and disperse DU into the atmosphere and potentially exacerbate the residual radiation doses.

2.3 CUMULATIVE EFFECTS

The cumulative environmental effects of the Proposed Action coupled with the impacts of other Federal, non-Federal, and private actions were evaluated and no reasonably foreseeable actions were identified as occurring simultaneously with the Proposed Action. FWS will continue to operate the Big Oaks NWR and INANG for USAF will continue to operate the Jefferson Range in accordance with the MOA (U.S. Army 2000a). The continued ownership of the land north of the firing line by the Army will prohibit the development of approximately 50,950 ac (206 km^2) of land for any other uses. However, the presence of UXO prohibits land use and continued Army ownership will act as an institutional control to further prevent land use.

Most of the acreage south of the firing line is considered to be prime mixed development property and has been or will be sold to a private individual. To date, 2,485 ac (10 km^2) have been transferred from Army control to a private individual. Two parcels of property south of the firing line were given to Jefferson County as public parks totaling approximately 635 ac (2.56 km^2) and lastly, 1 ac (0.004 km^2) south of the firing line along with approximately 17 mi (27 km) of railroad tracks all south of the firing line were sold to the Madison Port Authority. An additional 1,212 ac (4.9 km^2) are planned to be transferred. All of the transferred and transferring property is located in the southern portion of JPG. Therefore, no cumulative impacts beyond those from the Proposed Action were identified.

2.4 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

A comparison of the predicted environmental impacts for the alternatives is presented in Table 2-1. The short- and long-term impacts for each environmental impact category are discussed further in Section 4.

Table 2-1. Summary of Predicted Environmental Impacts
Jefferson Proving Ground, Madison, Indiana

Environmental Impact	Alternative 1: License Continuation (No Action)	Alternative 2: License Termination Under Restricted Conditions (Proposed Action)
Land Use	Impacts identical to the Proposed Action.	No impacts. Land use of the DU Impact Area will remain restricted in accordance with the MOA (U.S. Army 2000a).
Transportation	No impacts.	No impacts.
Geology and Soil	Impacts identical to the Proposed Action.	No short-term impacts. Possible long-term impacts associated with uranium migration with soil depth.
Water Resources	Impacts identical to the Proposed Action.	No short-term impacts to either surface water or groundwater. Over the long-term, there could be localized fluctuations of uranium concentrations in surface water and groundwater from uranium migration, but fate and transport modeling presented in Section 3 indicates no adverse impacts.
Ecological Resources	Impacts identical to the Proposed Action.	No short-term impacts to biotic resources. Over the long-term, uranium could accumulate in biotic resources, but results from the deer sampling study (SAIC 2006a) suggest that accumulation is unlikely.
Air Quality	Impacts identical to the Proposed Action.	Possible short-term, local impacts with resuspension of DU particulates and oxides (low probability event), but residual radiation doses associated with the inhalation pathway are negligible, as shown in Section 4 of the Decommissioning Plan (U.S. Army 2013a).
Noise	No impacts.	No impacts.
Historic and Cultural Resources	No impacts. DU Impact Area previously was disturbed by ammunition testing.	No impacts as there are no historic or cultural resources within the DU Impact Area.
Visual/Scenic Resources	No impacts.	No impacts.
Socioeconomic Impacts	No impacts.	No impacts.
Environmental Justice	No impacts.	No impacts.
Public and Occupational Health	Impacts identical to the Proposed Action.	If institutional controls are maintained, both UXO and radiological hazards would be minimized. UXO hazards and risks predominate and could result in injury or fatality. Radiological impacts to site workers and members of the public would be a few mrem/y and below the NRC restricted release criterion of 25 mrem/y applicable with institutional controls. With a loss of institutional controls, the potential for additional radiation exposure would increase. The site hazards would be dominated by the presence of UXO. The radiological impact for all land uses would be less than 100 mrem/y applicable in the event of loss of institutional controls (see dose assessments in Appendix C of the Decommissioning Plan).
Waste Management	No impacts.	No impacts.

DU = Depleted Uranium
MOA = Memorandum of Agreement
NRC = U.S. Nuclear Regulatory Commission
UXO = Unexploded Ordnance

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3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

This section describes the baseline environmental conditions for the Jefferson Proving Ground (JPG) in general and the Depleted Uranium (DU) Impact Area in particular as available. In Section 4, the various decommissioning alternatives described in Section 2 are evaluated with respect to their potential impacts on the environment, based on the baseline conditions defined in Sections 3.1 through 3.12.

3.1 LAND USE

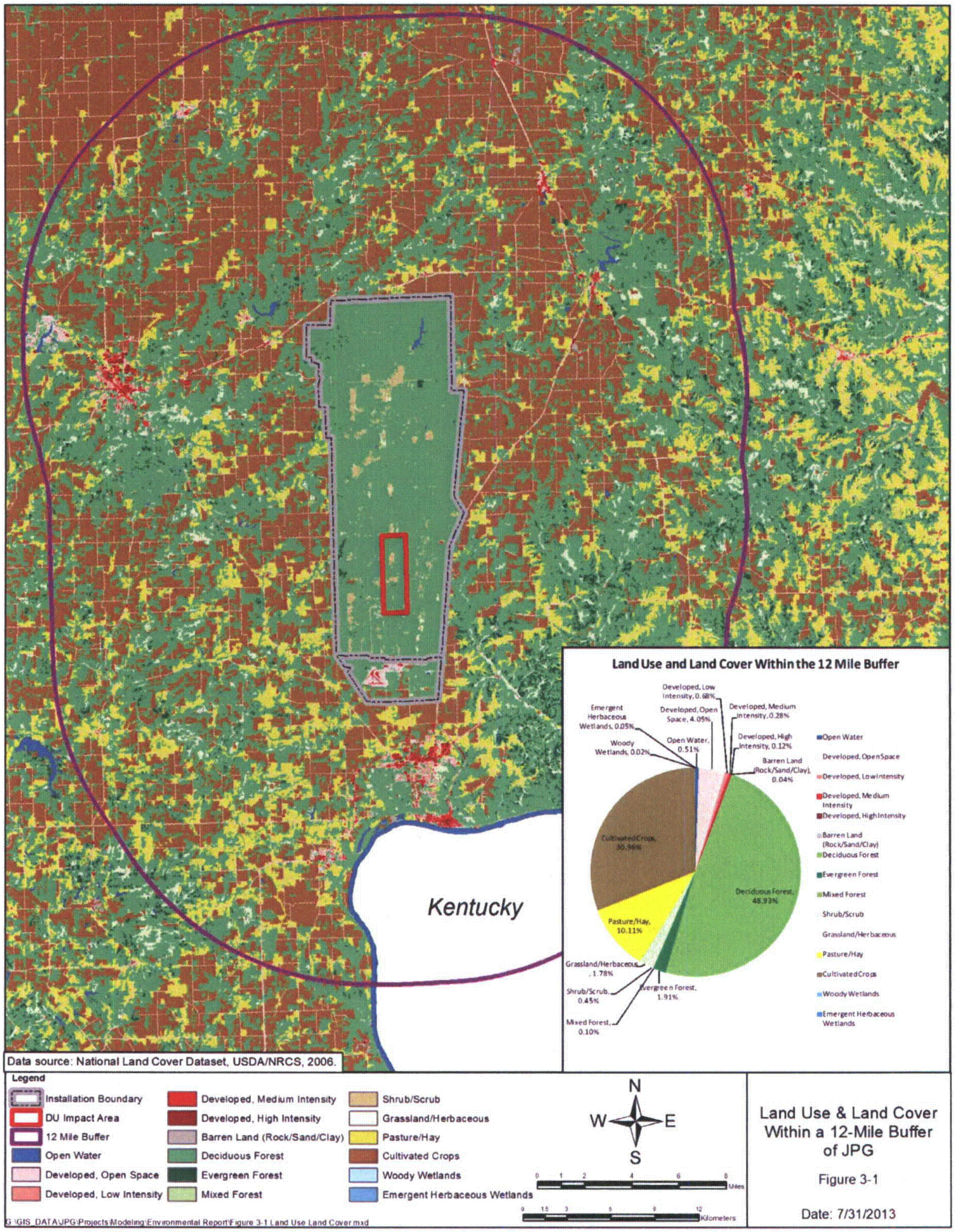
As shown in Figure 3-1, the majority of land on and around JPG is covered by deciduous forest (62.0 percent), cultivated crops (24.3 percent), pasture/hay (6.5 percent), open developed space (2.8 percent), and shrub/scrub (2.6 percent) (MRLC 2006). The remaining nine land use categories shown in Figure 3-1 represent less than 2 percent of the total of land uses/covers within a 12-mile (mi) (19-kilometer [km]) buffer that includes and surrounds JPG. The land covered by JPG, particularly north of the firing line and within the DU Impact Area, contrasts somewhat with the surrounding land uses/covers. JPG primarily is covered by forests (deciduous and evergreen), shrub/scrub, and grassland/herbaceous.

The adjacent land use has changed little since the establishment of the installation in the 1940s and has been used predominantly for small family farms since the early 1800s, although several small rural towns are located near JPG (e.g., Madison, Vernon, North Vernon, Versailles). Approximately 200 farmhouses and other dwellings are located within 1 mi (1.6 km) of JPG south of the firing line. The major local crops are tobacco, corn, and soybeans.

The U.S. Fish and Wildlife Service (FWS) established the Big Oaks National Wildlife Refuge (NWR) in the area north of the firing line in June 2000. Under a negotiated Memorandum of Agreement (MOA) between the Army, U.S. Air Force (USAF), and FWS (U.S. Army 2000a), the Army retains ownership of the land and FWS will operate the Big Oaks NWR on a 25-year lease with 10-year renewal options. The Big Oaks NWR encompasses approximately 51,000 acres (ac) (206 square kilometers [km^2]), including the DU Impact Area. As shown in pink in Figure 3-2, access to approximately 24,000 ac (97 km^2) of land is restricted by FWS within the refuge primarily because of the occurrence of high levels of unexploded ordnance (UXO), but also both UXO and DU in and near the DU Impact Area.

The MOA included a Public Access Plan that was updated in 2012 (FWS 2012), which identifies requirements and protocols for public access to the Big Oaks NWR. This plan also outlines FWS-, Army-, and USAF-related responsibilities regarding safety briefings, entry procedures, public use types, accessibility areas, public use monitoring, limiting, and controlling procedures, key control, and use of refuge by Old Timbers' lodge guests. Table 3-1 (FWS 2012) succinctly summarizes public use limits for the Big Oaks NWR. Figure 3-2 shows public access areas and restrictions, Indiana Air National Guard (INANG) training ranges, and Old Timbers Lodge.

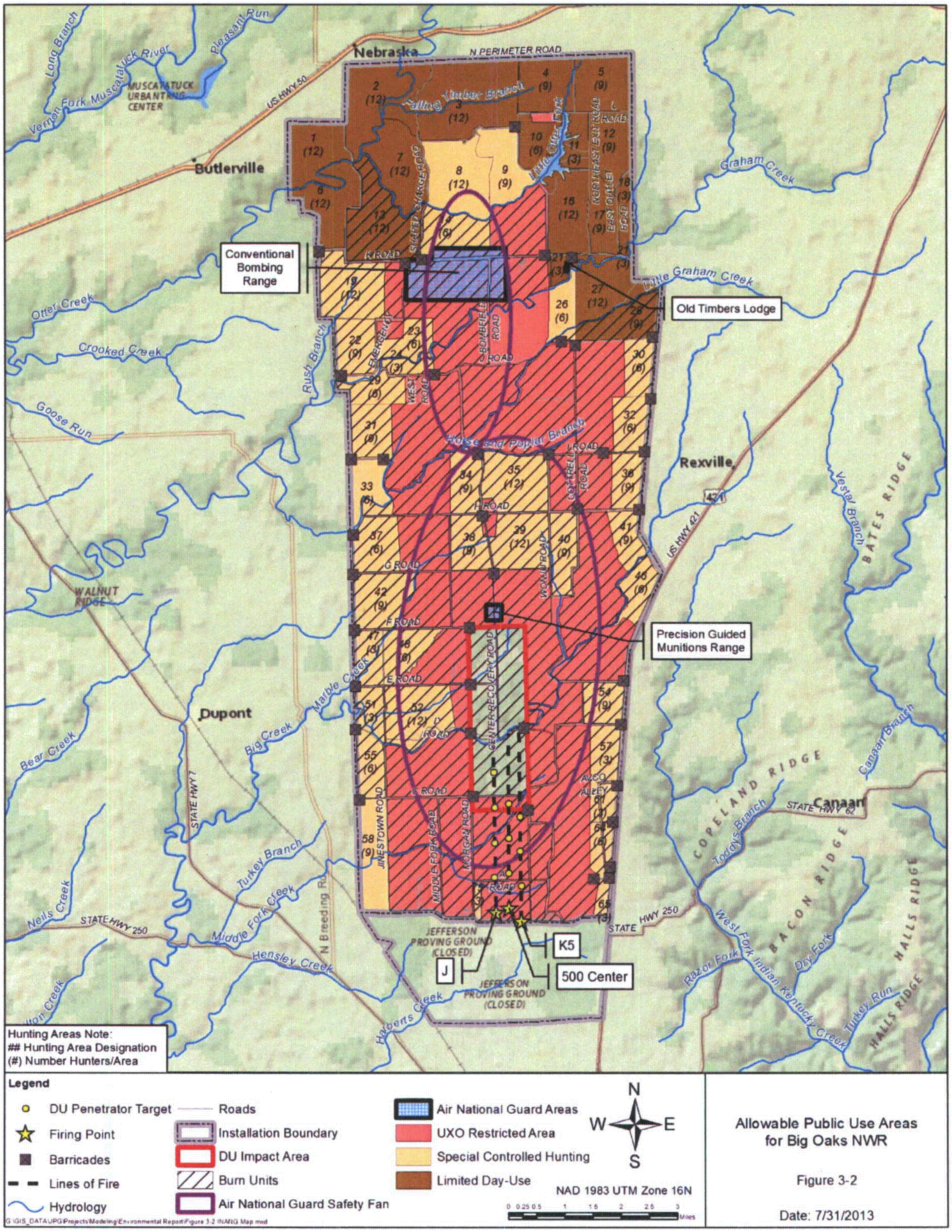
Visitors to the Big Oaks NWR must check in and out and receive a safety briefing at the refuge office before being issued a public access permit. Public access to the refuge is controlled strictly at one gate and is limited to two areas (Figure 3-2): limited day-use recreation and special controlled hunting zones. All of these recreational areas were used previously in the Army recreation program. Public use areas are delineated by maps provided to visitors and by signs placed at strategic locations within the Big Oaks NWR.



Land Use & Land Cover Within a 12-Mile Buffer of JPG

Figure 3-1

Date: 7/31/2013



Allowable Public Use Areas for Big Oaks NWR

Figure 3-2

Date: 7/31/2013

Table 3-1. Public Use Limits for Big Oaks NWR[a]
Jefferson Proving Ground, Madison, Indiana

Activity	Description Where Use Will Occur	Maximum One-Time Capacity	When Allowed
Deer Hunting	See Figure 3-2	500	November (6 days for archery and 9 days for gun)
Spring Turkey Hunting	See Figure 3-2	220	April to May (15 days)
Fall Turkey Hunting	See Figure 3-2 (concomitant with deer archery season)	500	October (14 days)
Squirrel Hunting	See Figure 3-2	72	Mid-August through November; 5 to 10 days per month
Fishing	Maximum of 30 boats on Old Timbers Lake; no fishing allowed on any other body of water	200[b,c]	5 to 10 days per month; April through October
Collecting (mushrooms, berries, shed deer antlers)	Maximum number of persons/area given on Figure 3-2 for areas designated for collecting, same as turkey hunting	2[d]	5 to 10 days per month; April through November
Wildlife Observation and Photography	Half of the number of persons/area for areas given on Figure 3-2; only for Limited Day Use Zone	80[b]	5 to 10 days per month; April through November
Guided Tours (interpretation and environmental education)	Dependent on conveyances available by activity; by definition, accompanied by FWS staff	50	By reservation

[a] Based on staff and available funds.
[b] Based on available parking for special events.
[c] Special event one-time capacity.
[d] Collecting may occur in Special Control hunt areas during turkey hunting or same areas designated for squirrel hunting on Figure 3-2.

In support of its responsibilities under the MOA, FWS has issued several other related documents. These documents include an Interim Comprehensive Conservation Plan (FWS 2001a), a Big Oaks NWR Interim Hunting and Fishing Plan (FWS 2001b), an Interim Compatibility Determination (FWS 2001c), a Fire Management Plan (FMP) (FWS 2006), a Biological Assessment for Modification of Prescribed Fire Dates for Big Oaks NWR (FWS 2010a), and an Environmental Assessment (EA) (FWS 2001d). The FMP describes the goals, objectives, and procedures for implementing prescribed fires within the Big Oaks NWR. Prescribed burns are used to enhance habitat critical to maintain the diversity of plant community and associated wildlife species. Two of the four fire management units outlined in this plan encompass the DU Impact Area. The EA addresses the impact of implementing the FMP at the Big Oaks NWR. The FWS determined that this Proposed Action would have no significant impact on the environment. Accordingly, a Finding of No Significant Impact (FONSI) was issued (FWS 2001e).

INANG also operates a bombing range north of the firing line. The bombing range includes an approximately 50-ac (0.2-km^2) Precision-Guided Munitions (PGM) range, an approximately 983-ac (4-km^2) conventional bombing range, and approximately 5 ac (0.02 km^2) associated with the Old Timbers Lodge (Figure 3-2). These areas are excluded from the real estate permit for the refuge.

When in use, the bombing ranges have large safety fans, as shown in purple in Figure 3-2. FWS personnel and visitors are excluded from the bombing ranges (inclusive of the safety fan in use) during flight operations involving training munitions or laser energy (U.S. Army 2000a). The primary training range has a composite footprint of approximately 5,100 ac (20.6 km^2). The PGM range has a composite footprint of approximately 15,000 ac (60.1 km^2) (Figure 3-2). During flight operations, only INANG personnel are permitted access into the weapons safety footprints. When INANG is not using the safety footprints, FWS has access to this area. Access to the range is controlled through four gates. INANG personnel maintain and inspect the JPG perimeter fence. INANG also maintains the barricades on access roads to the footprint of the PGM range and interior areas north of the firing line. These barricades are located where the interior roads exit to the eastern and western perimeter roads. INANG also currently maintains UXO safety signs on the perimeter fence and gates, as well as "Caution, Radioactive Materials" signs around the perimeter of the DU Impact Area.

To date, 2,485 ac (10.0 km^2) located south of the firing line have been transferred from Army control to a private individual. Two parcels of property south of the firing line were given to Jefferson County as public parks totaling approximately 635 ac (2.56 km^2) and lastly, 1 ac (0.004 km^2) south of the firing line along with approximately 17 mi (27 km) of railroad tracks all south of the firing line were sold to the Madison Port Authority. An additional 1,212 ac (4.9 km^2) are planned to be transferred. All of the transferred and transferring property is located in the southern portion of JPG. This property is used for light industrial, commercial, agricultural, and residential purposes.

3.2 TRANSPORTATION

JPG includes 196 mi (315 km) of improved roads, 22 bridges, and 10 low water crossings. Improved roadways of concrete or asphalt surface total 34 mi (55 km), and gravel surfaced roads constitute the remainder of the road network. There are also some unimproved roads on the installation. Most of the roads are in good condition. Sections at low water crossings of the West Perimeter Road, East Perimeter Road, and a section of K Road east of Machine Gun Road are the only paved roads in the test range area (U.S. Army 1995c). Under the MOA, INANG and FWS share responsibilities for infrastructure maintenance north of the firing line.

Three interstate highways are near JPG. Interstate 65, running north-south, is 30 mi (48 km) to the west. Interstate 71, running east-west, is 30 miles to the southeast. Interstate 74, running east-west, is 45 mi (64 km) north of JPG. Access to the installation is via Route 421, a two-lane road following a portion of the eastern border of the installation.

Prior to closure in 1995, JPG had an airfield that was constructed in 1941 to handle bombers and large cargo aircraft. It consisted of four concrete runways, two approximately 5,000 feet (ft) (1,524 meters [m]) long and two measuring 4,500 ft (1,372 m) in length. There are 507,000 square feet (ft^2) (47,102 square meters [m^2]) of taxiways and 349,000 ft^2 (32,423 m^2) of apron area. The hangar (Building 301) has 24,084 ft^2 (2,237 m^2) of floor space. During the early 1960s, the airfield was closed to fixed wing aircraft. Due to deteriorating runway conditions and outdated equipment for airspace control, the airport has remained closed to all air traffic. Prior to closure in 1995, the runways showed signs of concrete spalling and reinforcing steel bars in the runway were visible in some places. The airfield is presently closed.

The rail system that existed at JPG was transferred to the Madison Port Authority under the Base Realignment and Closure (BRAC) program after closure. The Madison Railroad (MRR), a division of the city of Madison Port Authority, is a 25-mi (40-km) short line operating from Madison to North Vernon, Indiana. The railroad acquired an engine house, 17 mi (27 km) of track, of which 10 mi (16 km) is for car storage use on a short- or long-term basis, and a loading dock located on JPG. As a result of this acquisition, the railroad now offers transloading and car storage (see http://www.madisonrailroad.com/services.php).

Some of the gravel/dirt roads become flooded at times as they are located in low-lying areas with poor drainage and/or near beaver dams, such as the beaver dam shown in Figure 3-3. This particular dam was built on the north tributary of Big Creek (near the intersection of F Road and Morgan Road) and did not impact travel on this occasion but is included to demonstrate the widespread impacts of beaver dams on JPG. This beaver dam was approximately 4 ft (1.2 m) high and 180 ft (55 m) long.

The northern and southern boundaries of the DU Impact Area are F Road and slightly south of C Road, respectively. Morgan Road and Wonju Road form the western and eastern boundaries, respectively (see Figure 3-2). All roads approaching the DU Impact Area are currently barricaded with pad locked metal swing gates (locations of barricades are shown in Figure 3-2). At the southern end of the DU Impact Area, C Road crosses the entire width of the licensed area with gates at both ends where C Road intersects with Wonju Road on the east and Morgan Road on the west. The bridges that cross over Big Creek on Morgan Road (near the intersection with D Road) and D Road (near Center Recovery Road) are

Figure 3-3. Beaver Dam on Northern Tributary of Big Creek

no longer safe to use, thereby limiting vehicle traffic through the DU Impact Area. Upon license termination, the Army will no longer maintain the swing gates approaching the DU Impact Area because these barricades are a requirement of the license, but gates will be at fencing that surrounds the area north of the firing line.

3.3 GEOLOGY AND SOILS

JPG is located on the western flank of the Cincinnati Arch, a broad structural feature that separates the Illinois and Appalachian Basins (Figure 3-4). Most of the installation is covered by a layer of Pleistocene glacial deposits that overlies Paleozoic bedrock. The underlying bedrock consists of interbedded limestone, dolomite, and shale. Information on JPG's hydrostratigraphic units and seismology are provided in Sections 3.3.1 and 3.3.2, respectively. More detailed information about geology and soils is included in the conceptual site model (CSM) (Appendix C), groundwater modeling (Appendix B), distribution coefficient (K_d) study (Appendix D), and other references presented below and included in these appendices.

3.3.1 Hydrostratigraphic Units

Hydrostratigraphic units at the DU Impact Area include overburden and bedrock. Overburden is defined as unconsolidated sediments occurring above the bedrock and consists mainly of soils, loess, and glacial till with minor amounts of alluvium deposited along streams. The underlying bedrock consists of interbedded limestone, dolomite, and shale. The upper portion of the bedrock referred to here as shallow bedrock (upper 40 to 60 ft [12.2 to 18.3 m] of bedrock) is more permeable than deep (bedrock below 40 to 60 ft [12.2 to 18.3 m]) bedrock.

3.3.1.1 Overburden

The entire DU Impact Area has undergone anthropogenic disturbance of various types and magnitude. Prior to the establishment of JPG, the majority of the land was agricultural and the soils were

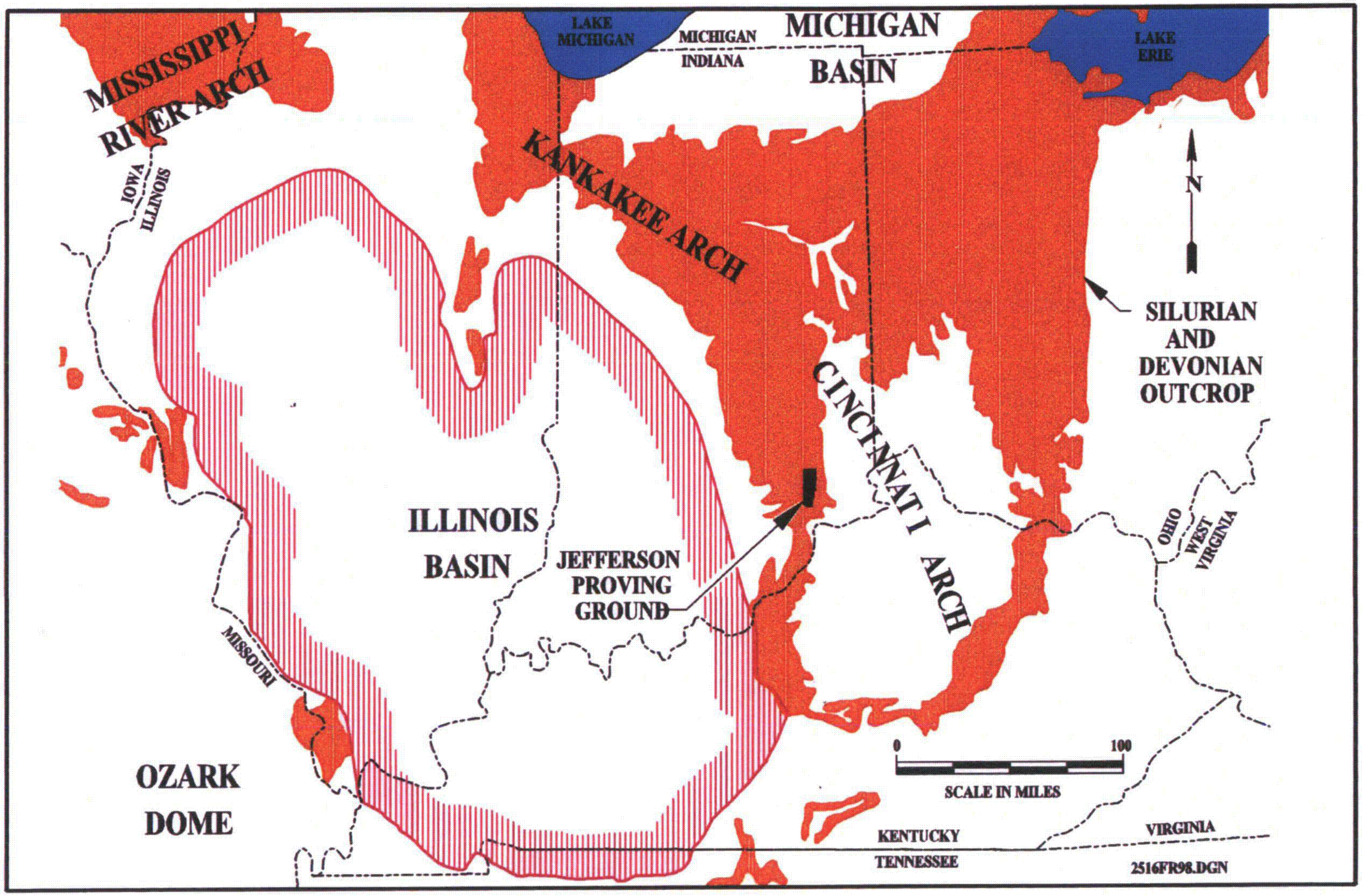


Figure 3-4. Regional Structural Setting of Jefferson Proving Ground

disturbed in the act of tilling the lands. Following the establishment of JPG, disturbances ranged from installation and maintenance of the infrastructure (e.g., utility trenching, construction of buildings/structures, road building) to testing operations in impact fields (i.e., disturbance by detonation) for a great number and variety of ordnance between 1941 and 1994.

Monitoring well boring logs exist for the wells within the DU Impact Area as well as for additional wells south of the firing line. Observations and sampling during borehole advancement serves as the primary data source on subsurface conditions at JPG. The overburden consists of the unconsolidated materials or overburden (glacial tills and loess) present above the bedrock. As determined from the well installation and well logs, the depth of the overburden materials range from 0.65 to 72.5 ft (0.2 to 22.1 m), with an average depth to bedrock of 20.8 ft (6.3 m).

Loess occurs above the glacial till. The boundary between the loess and glacial till is transitional and not sharply defined due to similarities in lithology; most loess is derived from the underlying glacial till. The presence of gravel and split spoon blow counts (a substantial increase in blow counts was used to indicate the presence of till) is used in this effort to differentiate loess (aerially deposited) from the underlying till (glacially deposited). Review of the site characterization well logs shows loess thickness to ranges from 0 to 11 ft (0 to 3.4 m) with an average of 6.3 ft (1.9 m). Environmental Radiation Monitoring (ERM), Range Study, and site characterization well logs show slightly greater depth to the glacial till but with less precision. This is because the borings were completed with split spoons (and therefore lithology descriptions) at 5-ft intervals in the overburden.

A soil verification study (SVS) (SAIC 2007a) was conducted to confirm the soil series as mapped by the U.S. Department of Agriculture (USDA). Results from the field observations indicate the soil mapping units delineated on the Natural Resources Conservation Service (NRCS) map are reasonably accurate. Seven soil series are mapped in the DU Impact Area (USDA NRCS 2005): Avonburg, Cincinnati, Cobbsfork, Grayford, Holton, Rossmoyne, and Ryker. The soil in the study area is composed of mostly fine-grained materials, which appear to have a low permeability. From the soil borings observed, the site soil conditions may be wetter than indicated by the NRCS soil survey map. All seven soil series have similar texture, consisting of silt loam derived from different parent materials and having different slopes. Six soil series are derived from parent material consisting of loess, underlying till-derived paleosols, and limestone residuum, and one soil series is derived from alluvium on floodplains:

- ***Avonburg Series***—Very deep, somewhat poorly drained soils formed in loess and underlying paleosol in till
- ***Cincinnati Series***—Deep, well-drained soils formed on mantle of loess
- ***Cobbsfork Series***—Poorly drained soils on broad summits of till plains; formed in loess and underlying till-derived paleosols
- ***Grayford Series***—Deep, well-drained soils formed in loess, till of Illinoian age, and residuum from limestone on dissected till plains and sinkholes
- ***Holton Series***—Deep, poorly drained soils formed in loaming alluvium on floodplains
- ***Rossmoyne Series***—Very deep, moderately well-drained soils formed on mantle of loess and underlying till of Illinoian age
- ***Ryker Series***—Very deep, well-drained soils formed in loess, underlying drift, and residuum from limestone on till plains.

The portion of the DU Impact Area (>55 percent) with somewhat poorly and poorly drained soil exhibits redoximorphic features (soil mottling) that indicate a reducing environment exists in the shallow (<3 ft [0.9 m]) subsurface for some period of time during the growing season. Redoximorphic features or soil drainage mottling are color patterns in the soil formed by the oxidation and reduction of iron and/or manganese caused by saturated or near saturated conditions within the soil. This reducing environment is sufficient to reduce the ferric iron to ferrous iron (i.e., the presence of ferrous or ferric iron is an indicator of the oxidative state). No direct measurements of oxidation-reduction (redox) potential (Eh) for soil were obtained during this investigation. Corrosion of metals and, therefore, DU penetrators can be greatly affected by the environment in which they are located. DU penetrator corrosion rates and processes are much lower under reducing conditions than those present under oxidizing conditions.

Site-specific K_d was measured at JPG to characterize how DU may adsorb to or desorb from site soils during fate and transport. In summary, sorption tests showed lowest K_d (lowest fraction of uranium portioning onto the till) for groundwater in glacial tills. Sorption tests for soils at the surface showed high K_d (uranium strongly sorbed to soils). Desorption-dissolution tests indicated a higher fraction of uranium will partition to rainwater in contact with highly impacted soils beneath or near the penetrators.

3.3.1.2 Bedrock Zone

The depth to carbonate bedrock ranges from less than 1 to 72.5 ft (0.3 to 22.1 m) below ground surface (BGS). Relief on the top of bedrock is nearly 100 ft (30.5 m) with the top of bedrock ranging in elevation from 784.93 to 888.92 ft (239.4 to 270.9 m) above mean sea level (msl). In addition to the bedrock picks developed in the boring logs, additional information was obtained from a bedrock topographic map from the state of Indiana's Geographic Information System (GIS) Atlas (http://maps.indiana.edu/).

A karst study to identify caves was conducted at the installation from 1994 to 1997 along five creeks: Big Creek, Middle Fork Creek, Graham Creek, Little Graham Creek, and Otter Creek (Sheldon 1997). During this inventory, 32 caves with 52 entrances were identified. The cave lengths ranged from approximately 26 ft (7.9 m) to the longest cave length of 1,507 ft (459 m). Nineteen caves were identified along Big Creek, with an average cave length of approximately 162 ft (49.4 m).

Karst features observed at JPG and specifically within the DU Impact Area consist of surface expressions of small sinkholes, caves along Big Creek, and weathered jointing (fracturing) of bedrock observed at outcrops along Big Creek. Caves and solution features appear to be most commonly above the groundwater table and above the elevation of Big Creek. Wells were located on fracture traces and using geophysical techniques to selectively test areas where karst development would be greatest. However, results of the well drilling, field observations, and an analysis of published reports and previous studies demonstrate that karst activity within and immediately surrounding the DU Impact Area is limited in depth and lateral extent, confined to the shallow bedrock (generally less than 50 ft [15.2 m] BGS), and more prevalent in and adjacent to stream valleys:

- Of all of the new wells installed, only a single very minor solution feature was observed in each of the borings at the JPG-DU-02 well pair location (along Big Creek) at a depth of 23 to 23.5 ft (7 to 7.12 m) BGS. The absence of karst/weathered conditions in 19 borings cored in 10 locations that were expected to be preferentially developed demonstrates that karst weathering is not a predominant feature in the DU Impact Area.
- Karst development and the presence of a karst controlled groundwater flow network appears to be limited to within the narrow erosional plain along Big Creek and offsite along lower sections of Middle Fork Creek. Observations by Science Applications International Corporation (SAIC) soil scientists and geologists indicate no sinkholes or closed depressions in the elevated areas above this plain. Sheldon (1997) reported on extensive field reconnaissance work completed from January 1994 to April 1997 in and surrounding the DU Impact Area, in which caves, sinkholes, and karst features were recorded and catalogued. Sheldon's only reported, observed,

and documented cave locations within the DU Impact Area were along Big Creek (Sheldon 1997).

- The observations of karst features and weathering onsite concur with the following statements by Herring (2004), "...the majority of sinkholes or depressions occur along the larger stream valleys (especially Big Creek)...," "...water well records...indicate a few feet of crevices, broken limestone, or mud seams within the limestone bedrock, generally at depths less than 50 feet below land surface...," and "...The Silurian carbonates...show limited karst development in Jefferson County. These rocks contain thinner limestones and more layers of shale, conditions that significantly limit karst development."

3.3.1.3 Geotechnical Properties

Grain size analysis of 26 loess soil samples indicates the 3 shallow loess soil types have very similar grain size distributions consistent with the field-determined silty clay and sandy loam soil descriptions made at the time of sampling. The three loess soil types are very similar, containing approximately 29 to 33 percent clay, 45 to 52 percent silt, 18 to 23 percent sand, and 1 percent or less gravel. Figure 3-5 shows the relative differences in grain sizes for the three soils. This textural composition is consistent with a silty clay to clayey silt loam.

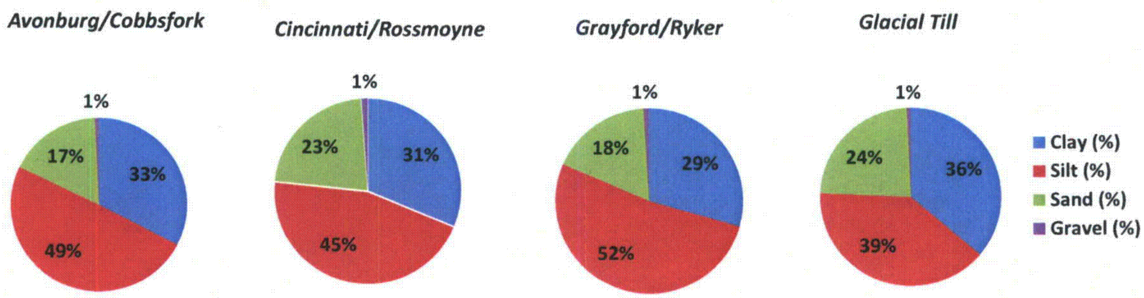


Figure 3-5. Particle Size Comparison of JPG Soil Types

The published range of porosity in glacial till is 12 to 41 percent with an average value of 26 percent (Kresic 2007). The published range of porosity in loess is 44 to 57 percent with an average value of 49 percent (Kresic 2007). Published bulk density of overburden materials is 1.92 grams per cubic centimeter (g/cm^3) (Telford, Sheriff, and Geldart 1990).

The published range of porosity in dolomite is 1 to 32 percent with an average value of 7 percent (Kresic 2007). For limestone, the published range in porosity is 0 to 65 percent with an average value of 8 percent. Specific yield in carbonate bedrock is reported at 1 to 5 percent (USATHAMA 1988). Bulk density of limestone ranges from 1.92 to 2.90 g/cm^3; dolomite bulk density ranges from 2.28 to 2.90 g/cm^3 (Telford, Sheriff, and Geldart 1990).

3.3.2 Seismology

The history of seismic hazards within 124 mi (200 km) of JPG was obtained from the U.S. Geological Survey (USGS) (see http://earthquake.usgs.gov/earthquakes/eqarchives/epic/) and Indiana Geological Survey (http://maps.indiana.edu/metadata/Geology/Seismic_Earthquake_Epicenters.html). A complete list of all historical earthquakes within 124 mi (200 km) of the site is listed in Table 3-2. The locations are shown in Figure 3-6. The table lists 70 earthquakes between 5 July 1827 and 30 December 2010 that ranged from 2 to 6 in magnitude.

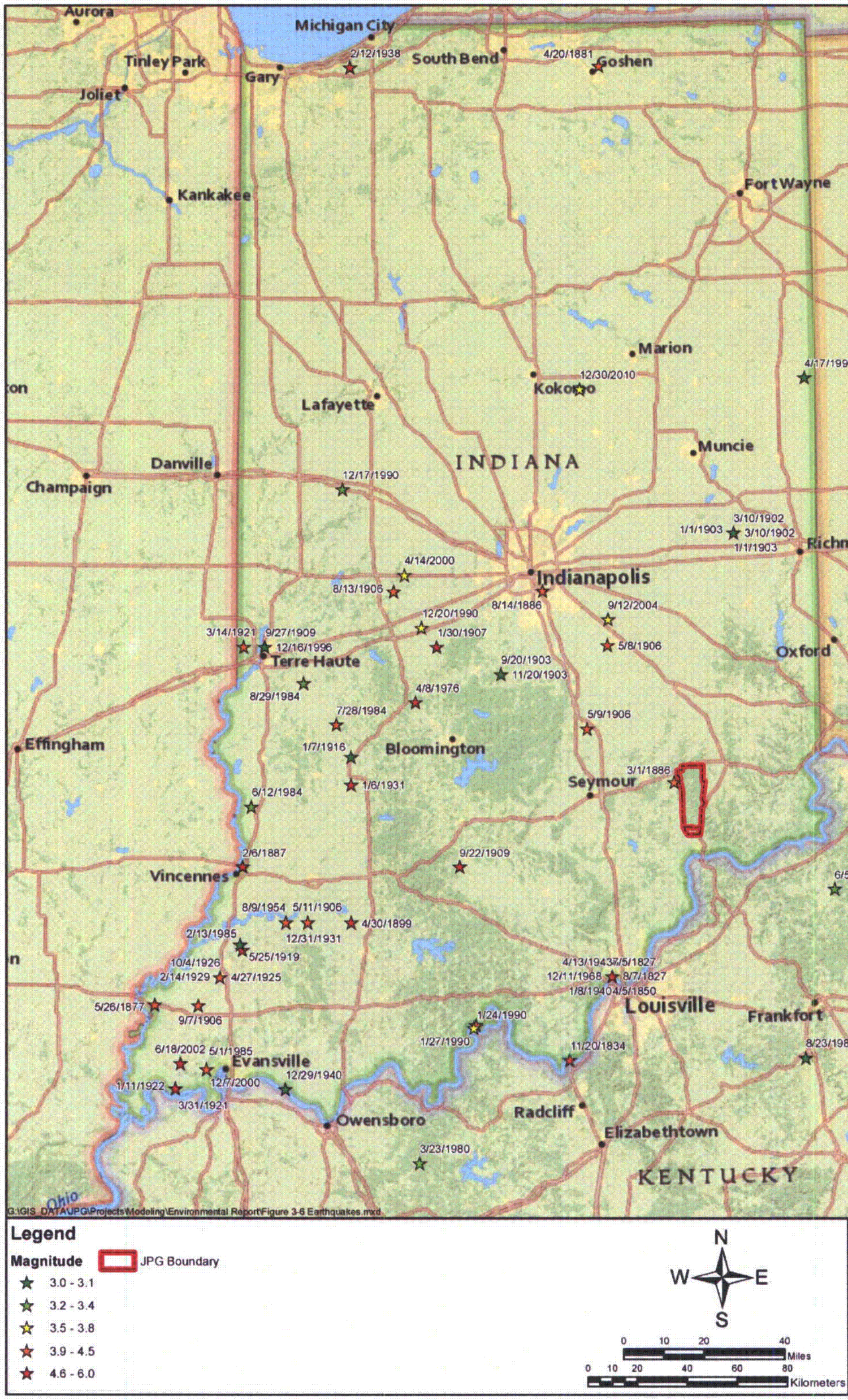
Table 3-2. Historical Earthquakes within 200 Kilometers of JPG Jefferson Proving Ground, Madison, Indiana

Source	Date	Longitude (degrees)	Latitude (degrees)	Depth (km)	Magnitude	Magnitude Code
Indiana	7/5/1827	-85.8	38.3	NA	6	c
Indiana	8/7/1827	-85.8	38.3	NA	6	d
Indiana	8/7/1827	-85.8	38.3	NA	6	d
Indiana	11/20/1834	-86	38	NA	5	d
Indiana	4/5/1850	-85.8	38.3	NA	5	d
Indiana	5/26/1877	-87.9	38.2	NA	4	d
Indiana	4/20/1881	-85.8	41.6	NA	4	d
Indiana	3/1/1886	-85.5	39	NA	4	d
Indiana	8/14/1886	-86.1	39.7	NA	4	d
Indiana	2/6/1887	-87.5	38.7	NA	6	c
Indiana	4/30/1899	-87	38.5	NA	4.8	c
Indiana	3/10/1902	-85.2	39.9	NA	4	d
Indiana	3/10/1902	-85.2	39.9	NA	4	d
Indiana	1/1/1903	-85.2	39.9	NA	3	d
Indiana	1/1/1903	-85.2	39.9	NA	3	d
Indiana	9/20/1903	-86.3	39.4	NA	4	d
Indiana	11/20/1903	-86.3	39.4	NA	3	d
Indiana	5/8/1906	-85.8	39.5	NA	4	c
Indiana	5/9/1906	-85.9	39.2	NA	4	d
Indiana	5/11/1906	-87.2	38.5	NA	4	c
Indiana	8/13/1906	-86.8	39.7	NA	4	d
Indiana	9/7/1906	-87.7	38.2	NA	4	d
Indiana	1/30/1907	-86.6	39.5	NA	5	d
Indiana	9/22/1909	-86.5	38.7	NA	5	c
Indiana	9/27/1909	-87.4	39.5	NA	4.8	c
Indiana	1/7/1916	-87	39.1	NA	3	c
Indiana	5/25/1919	-87.5	38.4	NA	5	c
Indiana	3/14/1921	-87.5	39.5	NA	4	c
Indiana	3/31/1921	-87.8	37.9	NA	4	d
Indiana	1/11/1922	-87.8	37.9	NA	5	c
Indiana	4/27/1925	-87.6	38.3	NA	4.8	c
Indiana	10/4/1926	-87.6	38.3	NA	3	d
Indiana	2/14/1929	-87.6	38.3	NA	4	c
Indiana	1/6/1931	-87	39	NA	5	c
Indiana	12/31/1931	-87.2	38.5	NA	2	d
Indiana	2/12/1938	-87	41.6	NA	5	c
Indiana	1/8/1940	-85.8	38.3	NA	3	d
Indiana	12/29/1940	-87.3	37.9	NA	3	c
Indiana	4/13/1943	-85.8	38.3	NA	4	d
Indiana	8/9/1954	-87.3	38.5	NA	4	d
Indiana	12/11/1968	-85.8	38.3	NA	5	e
USGS	6/5/1974	-84.77	38.6	15	3.2	NA
Indiana	4/8/1976	-86.7	39.3	NA	5	A
USGS	6/17/1977	-84.582	40.707	5	3.2	NA
USGS	8/23/1980	-84.922	37.995	5	3.1	NA
USGS	3/23/1980	-86.69	37.63	6	3.3	NA
Indiana	6/12/1984	-87.46	38.92	NA	3.4	MnSLM
Indiana	7/28/1984	-87.07	39.22	NA	4	MnSLM
Indiana	8/29/1984	-87.22	39.37	NA	3.2	MnSLM
Indiana	5/1/1985	-87.63	37.99	NA	2.9	MnSLM
Indiana	2/13/1985	-87.51	38.42	NA	3	MnSLM
USGS	7/12/1986	-84.371	40.537	10	4.5	NA
Indiana	1/24/1990	-86.43	38.13	NA	4.1	Mb

Table 3-2. Historical Earthquakes within 200 Kilometers of JPG Jefferson Proving Ground, Madison, Indiana (Continued)

Source	Date	Longitude (degrees)	Latitude (degrees)	Depth (km)	Magnitude	Magnitude Code
USGS	1/27/1990	-86.438	38.119	5	3.8	NA
Indiana	1/29/1990	-86.42	38.12	NA	2.9	MnGS
Indiana	4/17/1990	-84.85	40.46	NA	3	MnGS
Indiana	12/17/1990	-87.04	40.07	NA	3.2	MDSLM
Indiana	12/20/1990	-86.67	39.57	NA	3.6	MnBLA
USGS	4/4/1994	-84.4	40.4	5	2.9	mblg
Indiana	12/16/1996	-87.4	39.5	NA	3.1	MnGS
Indiana	3/6/2000	-87.53	38.1	NA	2.5	MnGS
Indiana	4/14/2000	-86.75	39.76	NA	3.6	MnSLM
Indiana	8/26/2000	-87.28	38.1	NA	2.6	MnSLM
Indiana	12/7/2000	-87.66	37.97	NA	4	MnSLM
Indiana	6/18/2002	-87.78	37.99	NA	5	MnSLM
USGS	1/30/2004	-84.65	40.67	5	2.5	mblg
USGS	9/12/2004	-85.796	39.594	6.1	3.8	NA
USGS	3/13/2005	-84.62	40.67	5	2.2	mblg
USGS	9/30/2008	-84.31	40.41	5	2.8	mblg
USGS	12/30/2010	-85.914	40.43	5	3.8	mwr

a = Magnitude determined from seismographic data
b = Magnitude determined from fall-off intensity with epicentral distance
c = Magnitude determined from felt area
d = Magnitude determined from epicentral intensity
e = Very shallow earthquake, with relatively large epicentral intensity and small magnitude and felt area
mb = Average NEIS body-wave magnitude
mglg = Value calculated for area of North America east of Rocky Mountains
MDSLM = Coda-length magnitude
MnBLA = Nuttli magnitude; Nuttli 1973
MnGS = Nuttli magnitude; Nuttli 1973
MnSLM = Nuttli magnitude; Nuttli 1973
NA = not available
Indiana = http://maps.indiana.edu/metadata/Geology/Seismic_Earthquake_Epicenters.html
USGS = http://earthquake.usgs.gov/earthquakes/eqarchives/epic/



Seismic Activity Within 200 Kilometers of JPG

Figure 3-6

Date: 8/15/2013

3.4 WATER RESOURCES

The following sections use site-specific and regional data to describe the physical and hydrological characteristics of surface water (Section 3.4.1) and groundwater (Section 3.4.2) in the DU Impact Area and in the surrounding region.

3.4.1 Surface Water Hydrology

Surface water features are abundant at the installation and include ponds, lakes, streams, and wetland areas, along with numerous ephemeral streams, ponding sites, and wet areas. At least 10 ponds or lakes that vary in size from less than 1 to 165 ac (0.004 to 0.7 km^2) are located on the installation. No ponds or lakes are located on the DU Impact Area.

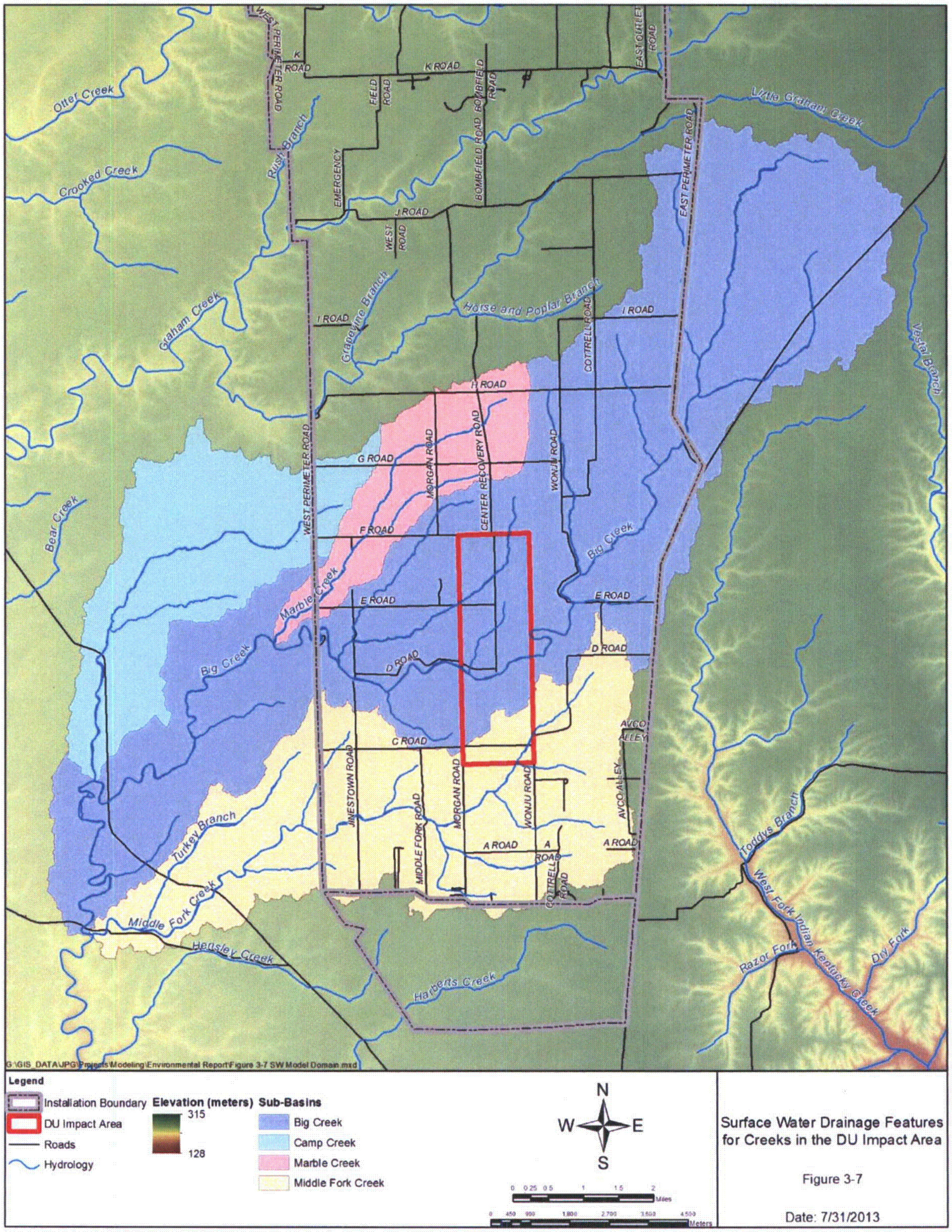
Seven streams and their tributaries drain the JPG area, generally flowing from northeast to southwest, and include Otter Creek, Graham Creek, Little Graham Creek, Marble Creek, Big Creek, Middle Fork Creek, and Harberts Creek (Figure 3-7). Flooding is common in southeastern Indiana because of the proximity to the Ohio River. Heavy rains may cause the tributaries of the Ohio River that cross JPG to swell (MWH 2002). Additional information about these creeks is provided below as well as in Appendices C and E, as well as additional references therein.

The DU Impact Area is within the Muscatatuck Plateau physiographic region and is characterized by broad uplands covered by glacial till with entrenched valleys (Gray 2001). The DU Impact Area is incised by two streams (i.e., Middle Fork Creek and Big Creek and associated tributaries). The surface relief generally is a result of erosion and down cutting associated with the streams and surface water flow to the streams. The surface water drainage is characterized as exhibiting a dendritic pattern that discharges to the streams.

Big Creek originates offsite and flows 9.7 stream mi (15.7 km) across JPG. It is fed by numerous unnamed intermittent tributaries and has a sandy/gravelly substrate with bedrock visible on the bottom and along the banks in many locations. Middle Fork Creek originates on JPG and is fed by several unnamed intermittent tributaries. It has a gravel substrate and meanders 3.9 mi (6.3 km) across the facility. Bedrock is visible on the bottom of Middle Fork Creek and along the banks in many locations within JPG, including the DU Impact Area.

Surface water gauging stations were installed in September 2006 (SAIC 2008a). Automatic, continuous, recording stream gauging stations were installed on Big Creek (three locations) and Middle Fork Creek (four locations), selected cave springs along Big Creek (two locations) inside the DU Impact Area, and one visual staff gauge along an unnamed tributary of Big Creek. The surface water gauging stations collected stream stage data at each location. Generally, the gauge stations consist of a stilling well and a pressure transducer/electronic data logger. Manual flow measurement locations were selected close to the stilling well locations in areas that had stream bank and bottom flow conditions conducive to collecting manual flows (e.g., flat bottom, clear of obstructions). Stage data and the corresponding manually measured flow rates were used to develop a rating curve for each station that was used to construct surface flow hydrographs for the streams at each gauge station.

Excluding the periods of time where flow exceeded the capacity of the weirs, flows from the cave springs ranged from 0 to 646 gallons per minute (gpm) (1.4 cubic feet per second [cfs]) in BC-11 and 0 to 355 gpm (0.8 cfs) in BC-12. Cave stream hydrographs show that the flow is extremely flashy, meaning that after precipitation events, the flow increases and decreases rapidly, causing the spiky nature of the hydrographs. The hydrographs showed periods of no-flow in all months except February through April, interrupted by sharp rises in flow as a result of precipitation events. These observations suggest that the cave stream networks feeding Big Creek and Middle Fork Creek are above the groundwater table most of the year.


Otter Creek
Crooked Creek
Rush Branch
Graham Creek
Grapevine Branch
Horse and Poplar Branch
Little Graham Creek
Vestal Branch
Bear Creek
Marble Creek
Big Creek
Turkey Branch
Middle Fork Creek
Hensley Creek
Harberts Creek
Toddys Branch
West Fork Indian Kentucky Creek
Razor Fork
Dry Fork
WEST PERIMETER ROAD
EAST PERIMETER ROAD
EAST OUTLET ROAD
K ROAD
FIELD ROAD
BOMBFIELD ROAD
EMERGENCY
J ROAD
WEST ROAD
I ROAD
H ROAD
G ROAD
F ROAD
E ROAD
D ROAD
C ROAD
A ROAD
MORGAN ROAD
CENTER RECOVERY ROAD
WONJU ROAD
COTTRELL ROAD
JINESTOWN ROAD
MIDDLE FORK ROAD
AVCO ALLEY
Legend
Installation Boundary
DU Impact Area
Roads
Hydrology
Elevation (meters)
315
128
Sub-Basins
Big Creek
Camp Creek
Marble Creek
Middle Fork Creek
N
W
E
S
Miles
Meters
Surface Water Drainage Features for Creeks in the DU Impact Area
Figure 3-7
Date: 7/31/2013

At each stage recorder location, the flow in the stream was measured manually using an in-stream flow meter. The methodology used to measure the streams is in accordance with the U.S. Environmental Protection Agency's (USEPA's) Wadeable Stream Assessment Field Operations Manual (USEPA 2004). Ten measurements were collected on most stations in the year after installation to collect a range of flow data at different stages, as the streams reacted to seasonal runoff flows. A comparison of the manual flow measurements and the corresponding stage indicates uncertainty in the measurements. Some measurements were impacted by log jams observed by field staff, and it was reasonable to exclude the data while developing the rating curve. The calculated discharge using the rating curve formula compared to the measured discharge shows a large degree of uncertainty in the measurements.

The poor correlation between recorded stage and measured flow is likely due to changing stream channel configuration caused by frequent storm flows, log and ice jams, and the numerous and changing beaver dams/pools, or field measurement error, especially at lower flow conditions where accurate measurement of flows using the flow meter methodology is difficult. Observations of the character of the stream stage hydrographs are useful. The following observations from these hydrographs about the stream flow characteristics are offered:

- The streams are extremely flashy, meaning that after precipitation events, the flow increases and decreases rapidly, causing the spiky nature of the hydrograph.
- The hydrographs showed a period of low- to no-flow for 4 to 6 weeks of the year, during June and July.
- The median discharge for the period of record ranges from 0.04 to 0.49 cubic feet per second per square mile (cfs/mi^2). Onsite stream hydrographs were compared to hydrographs from USGS gauging stations for the same time period.
- Station 03368000 is located 11.3 mi (18.2 km) northwest of the DU Impact Area boundary near Nebraska, Indiana. The gauge is on Brush Creek, with a drainage area of 11.4 square miles (mi^2) (29.5 km^2). From a review of topographic maps and aerial photographs, the drainage basin topography and land use/cover appear to be very similar to Big Creek, with mostly agricultural and wooded land use. The geology in both basins is nearly identical (Indiana Geological Survey 2002). The station has continuously recorded discharge from 1 June 1955 to the present day. The geology and topography of the basin are very comparable to the Big Creek and Middle Creek basins onsite. The basin had a median flow of 2.1 cfs (0.18 cfs/mi^2) for the period of interest, nearly identical on a unit area basis to the median flow measured in the three Big Creek gauges in the DU Impact Area (0.14 to 0.22 cfs/mi^2). The median flow for the entire period of record is 2.3 cfs (0.20 cfs/mi^2). Periods of low- to no-flow were common in late June through November. The hydrograph of this stream shows the same flashy nature as the hydrographs on Big Creek in the DU Impact Area.
- Station 03366500 is located 14 mi (22.5 km) southwest of the JPG DU Impact Area, on the Muscatatuck River near Deputy, Indiana. This station is downstream from and includes the JPG area and Brush Creek, and has been continuously recording discharge from 1 April 1948 to the present day. From a review of topographic maps and aerial photographs, the drainage basin topography and land use/cover appear to be very similar to Big Creek, with mostly agricultural and wooded land use. The geology of this basin compared to the Big Creek basin in and upgradient of the DU Impact Area appears to be very similar. The larger basin is underlain by bedrock units somewhat above and below the units exposed in the Big Creek Basin, but the rock types are very similar and should have similar hydrogeologic properties. The 296-mi^2 (766.6-km^2) basin had a median flow of 83 cfs (0.28 cfs/mi^2) for the period of interest, slightly higher than measured in the three Big Creek gauges in the DU Impact Area (0.14 to 0.22 cfs/mi^2). Periods of no flow were observed from July through November. The hydrograph of

this stream shows the same flashy nature as the hydrographs on Big Creek in the DU Impact Area.

The area is characterized by limited aquifer recharge and exhibits relatively low and decreasing permeability with depth. An analysis of hydrologic components suggests that surface water may be the most significant potential migration pathway from the DU Impact Area. The hydrographs from nearby USGS stream gauges and results from onsite stream gauges indicate that surface runoff after a precipitation event spikes rapidly and dissipates quickly, resulting in sharp rising and falling limbs. When stream flow rates are high, DU migration may include either sediment with DU attached and/or the disintegrated DU particles moving with the flow and followed by deposition downstream when flow velocities dissipate.

The water budget analysis (SAIC 2008a) determined that for an average precipitation year of 47 inches (in) (119.4 centimeters [cm]), 56 percent (26.3 in [66.8 cm]) is lost to evapotranspiration, 8 percent (3.8 in [9.7 cm]) becomes groundwater recharge, and the remaining 36 percent (16.9 in [42.9 cm]) is runoff. Weather data collected at Madison, Indiana (1976 to 2007) and from FWS located northeast of the DU Impact Area on JPG were used to determine evapotranspiration rates. During this period, annual precipitation ranged from 33.24 to 60.93 in (84.43 to 154.76 cm) and actual evapotranspiration ranged from 17.2 to 29.7 inches per year (in/y) (43.69 to 75.44 centimeters per year [cm/y]) (SAIC 2008a). Groundwater recharge rates were determined from base flow studies conducted for the neighboring Brush Creek and the larger Muscatatuck River to which Big Creek and all JPG streams are tributaries. For comparison, published estimates indicate groundwater recharge at 4 to 8 in/y (10.16 to 20.32 cm/y) for southern Indiana (Bechert and Heckard 1966). Brush Creek in particular demonstrates the extremely flashy nature that is observed within the JPG streams; Brush Creek is similar in size and hydrology to the JPG streams. Large runoff volumes are observed quickly following a precipitation event followed by a rapid fall off to base flow conditions. The SAIC (2008a) water budget assumes most of groundwater reemerges as base-flow into streams. Therefore, percolation losses to deep groundwater (deep bedrock) are insignificant.

Since transport of DU via surface water runoff represents a significant potential pathway for the migration of DU from the DU Impact Area and adjacent areas, the development of a numerical model (Appendix E) for JPG began with a model describing the area and key components of the surface water pathway, identification of data sources, and code selection. The modeled area (including the DU Impact Area) falls within the USGS hydrologic unit (0512020701) of the Muscatatuck River and is drained by Big Creek and Middle Fork Creek. Big Creek includes two smaller tributaries: Marble Creek and Camp Creek. The total area included for the surface water model extends to the confluence of Middle Fork Creek with Big Creek, covering a total area of roughly 44,949 ac (181.9 km^2) (Figure 3-7). The majority of this area consists of Big Creek with 25,160 ac (101.8 km^2); Marble Creek (3,053 ac [12.4 km^2]) and Camp Creek (5,843 ac [23.6 km^2]) occur downstream from the DU Impact Area. The Middle Fork Creek drainage area consists of 10,889 ac (44.1 km^2).

The land use patterns in the JPG watershed that could impact overland flow, including the potential transport of DU, are fairly diverse. Different erosion processes can mobilize and transport soil from the DU Impact Area to streams such as Big Creek or Middle Fork Creek. Rain falling on the land surface can detach soil particles, making them available to wash off in overland flow. Scouring of soils also can occur during precipitation runoff events. Land cover influences the amount of soil (or sediment) eroded. Farm land typically has greater erosion rates than forested or grass lands. Precipitation falling in upland areas of the watershed that were either uncultivated/bare or under active agriculture are expected to generate a large amount of sediment relative to the forested and grassy areas comprising the DU Impact Area.

This sediment and runoff will be transported by Big Creek and Middle Fork Creek through the DU Impact Area, where nonimpacted sediment and runoff from upstream will mix with the impacted sediment generated by erosion within the DU Impact Area. As this flow moves downstream from the DU Impact Area, additional mixing with nonimpacted sediment and runoff occurs. The cumulative output of sediment from the DU Impact Area is assessed in the modeling at points downstream from the area to the confluence of Middle Fork Creek with Big Creek (approximately 2 mi [3.2 km] from the site boundary). Additional information about surface water modeling is included in Appendix E.

Surface water is not used as a domestic drinking water supply in the vicinity of JPG; its primary use is for recreation and livestock watering (MWH 2002). Within the Big Oaks NWR, fishing is permitted only at the 165-ac (0.67-km^2) Old Timbers Lake (FWS 2001b). The streams have no segments listed in the Nationwide Rivers inventory, nor are they a part of the National Wild and Scenic Rivers System (Mason and Hanger et al. 1992). All surface water bodies at JPG are classified as "warm-water aquatic and full-body contact" by the State of Indiana water quality standards (Clark 1993).

3.4.2 Groundwater Hydrology

This section describes water levels (Section 3.4.2.1) and hydraulic conductivity (Section 3.4.2.2) in terms of the hydrostratigraphic units described earlier. Groundwater use and offsite groundwater wells are identified in Sections 3.4.2.3 and 3.4.2.4, respectively.

3.4.2.1 Water Levels

Water level data were collected periodically from wells installed at JPG. Results from these point measurements indicate the water level depths in overburden range from less than 2 ft (0.61 m) to nearly 40 ft (12.2 m) BGS and average 11 ft (3.35 m) BGS. Water levels in the shallow bedrock from wells that are paired with overburden wells are generally a few feet lower, but follow the same general patterns, indicating a downward gradient and hydraulic connection between the overburden and shallow bedrock. Water levels in deep bedrock wells are generally much lower than those in the shallow/intermediate bedrock and show very slow recovery following sampling or attempted slug testing, indicating limited communication between the shallow/intermediate and deep bedrock, and limited flow within the deep bedrock (at least at the locations of the installed monitoring wells).

Continuous recorders were installed in 15 of 43 monitoring wells within and adjacent to the DU Impact Area. Three general types of responses are noted:

- Overburden wells and intermediate wells located in upland areas away from creeks generally show seasonal fluctuations that range from a few feet to as much as 9 ft (2.74 m). A gradual decline in water levels occurred within these wells from late spring 2008 through the summer of 2008 during a period of below normal precipitation, followed by recovery to similar or in some cases higher water levels that preceded the decline. Monitoring wells showing this type of response include JPG-DU-01I, JPG-DU-03I, JPG-DU-06O, JPG-DU-06I, JPG-DU-09O, JPG-DU-09I, and MW-2.
- Shallow/intermediate bedrock wells near creeks exhibit similar response to changes in stream stage, indicating hydraulic connection between the shallow bedrock and adjacent creeks. Monitoring wells showing this type of response include JPG-DU-02I adjacent to Big Creek at the western boundary of the DU Impact Area and JPG-DU-05I adjacent to Middle Fork Creek at the eastern boundary of the DU Impact Area. One other monitoring well with a continuous recorder, JPG-DU-03I, was located adjacent to a tributary to Big Creek but did not show the same hydraulic connection to creek stage.
- Deep bedrock wells and some shallow/intermediate bedrock wells exhibit very slow recovery to sampling events or attempts to slug test the wells. These wells indicate the very low permeability within the bedrock at their respective locations. Monitoring wells showing this

type of response include JPG-DU-04D, JPG-DU-06D, JPG-DU-08I, JPG-DU-09D, MW-9, and MW-11.

Water level data from overburden and shallow/intermediate bedrock wells indicate flow directions roughly follow surface topography. Given the number of wells and spacing between wells, contour maps based upon observed water level data were not created. However, observations pertaining to flow directions and gradients can be made from the measured data. The direction of groundwater flow is roughly the same as the surface water drainage, which is to the west-southwest over most of the installation. The variability in the depth to groundwater in bedrock wells may reflect the occurrence of fractures in bedrock. SEC Donohue, Inc. (1992) noted that in the vicinity of incised surface drainages, the potentiometric surface slopes toward the streams at roughly the same gradient as the surface topography. Therefore, on a local scale, the bedrock groundwater tends to discharge to surface streams. Data from the site characterization wells, Range Study wells, and ERM wells support this observation.

3.4.2.2 Hydraulic Conductivity

Slug tests were performed on the wells in the vicinity of the DU Impact Area and the analysis is presented in SAIC (2010). Tables 3-3 (overburden) and 3-4 (shallow bedrock) (SAIC 2010) summarize the hydraulic conductivity results for each of the wells tested.

The hydraulic conductivity in the overburden and shallow bedrock is highly variable. Both zones included several wells where slug testing was not performed due to very slow water level recovery. The respective hydraulic conductivity in these cases is estimated to be at the low end of published literature values. Calculated hydraulic conductivities summarized below for both the overburden and shallow bedrock can be thought of as at the higher range of representative values at JPG but representative of the transmissible portions of each hydrostratigraphic zone.

The range in hydraulic conductivity values in overburden wells is from 0.0013 to 0.71 feet per day (ft/day) (0.01 to 5.3 gallons per day per square foot [gal/day/ft^2]) with a geometric mean for all overburden wells of 0.11 ft/day (0.85 gal/day/ft^2). The geometric mean for the overburden wells with JPG-DU-09O removed is 0.5 ft/day (3.74 gal/day/ft^2). The published range for till is approximately 1.3 to 1.3×10^{-6} ft/day (10 to 0.00001 gal/day/ft^2) (Freeze and Cherry 1979), putting the JPG average overburden hydraulic conductivity estimate in the upper range.

Table 3-3. Overburden Slug Test Results
Jefferson Proving Ground, Madison, Indiana

Well	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (ft/d)	Notes
JPG-DU-03O	2.4	0.32	
JPG-DU-04O	4.1	0.55	
JPG-DU-06O	5.3	0.71	
JPG-DU-09O	0.01	1.30E-03	
JPG-DU-10O	NA	NA	Very slow recovery
MW-10	NA	NA	Very slow recovery

Table 3-4. Shallow Bedrock Slug Test Results
Jefferson Proving Ground, Madison, Indiana

Well	Hydraulic Conductivity (gpd/ft^2)	(ft/d)	Notes
JPG-DU-01I	0.15	0.02	
JPG-DU-02I	18.55	2.48	Solution void
JPG-DU-03I	NA	NA	Very slow recovery
JPG-DU-04I	10.40	1.39	
JPG-DU-05I	0.08	0.01	
JPG-DU-06I	4.27	0.57	
JPG-DU-07I	NA	NA	No recovery
JPG-DU-08I	NA	NA	No recovery
JPG-DU-09I	NA	NA	Very slow recovery
MW-2	0.56	0.08	
MW-3	0.40	0.05	
MW-5	0.26	0.04	
MW-7	3.00	0.40	
MW-RS-2	10.20	1.36	

Hydraulic conductivity measured in overburden materials during the Final Phase II Remedial Investigation (RI) south of the firing line included the following results:

- Slug tests results ranging from 0.031 to 0.24 ft/day
- Matrix hydraulic conductivity ranging from 9.6×10^{-5} to 2.8×10^{-4} ft/day
- Small-scale fractures: 1.6×10^{-3} ft/day
- Large-scale fractures: 0.06 ft/day.

The geometric mean hydraulic conductivity value for shallow bedrock wells, including JPG-DU-02I where a 6-in solution void is present, is 0.18 ft/day (1.33 gal/day/ft^2). Without JPG-DU-02I, the geometric mean is slightly lower at 0.13 ft/day (0.99 gal/day/ft^2). The published range for limestone and dolomite is approximately 1.3 to 0.003 ft/day (10 to 0.02 gal/day/ft^2) (Freeze and Cherry 1979), putting the JPG hydraulic conductivity value on the upper end of the published range for limestone and dolomite and at the low end of solution enhanced, or karst limestone. Several wells could not be tested. Results from this untested well location would have shown a decrease in the shallow bedrock hydraulic conductivity.

Deeper bedrock permeability is clearly lower than overburden or shallow bedrock although remains unquantified due to the incomplete recovery of wells following development or incomplete recovery following installation of the data logger transducer/slug the night before testing. The above traits have led to a qualitative estimate of permeability for the deep bedrock on the order of 0.003 ft/day (0.02 gal/day/ft^2), which is at the low end of published values for limestone (Freeze and Cherry 1979).

In terms of the CSM, slug testing has quantified the permeability of overburden and shallow bedrock with values relatively similar for both hydrostratigraphic zones. Results suggest on a local scale that the overburden can transmit groundwater horizontally, possibly in discrete coarser-grained zones in the till, and that the till is likely in hydraulic communication with shallow bedrock. Slug test results confirm portions of each medium will essentially not transmit groundwater or transmit it very slowly. Water will reside for long periods of time in these low-permeability areas. The response of shallow bedrock well JPG-DU-02I to slug testing and the resultant hydraulic conductivity value estimate indicates that the shallow limestone may be more permeable on an average, large-scale basis than the overlying till, especially where the till is thin and rock is most susceptible to dissolution over time and subsequent enhanced fracture permeability.

Based on observed very slow recovery in deeper bedrock wells (e.g., following development and sampling) and the inability to conclusively slug test these wells relative to the hydraulic conductivity values for overburden and shallow bedrock, there is a pronounced reduction in average rock permeability below an average depth of 29 to 33 ft (8.84 to 10.06 m) into the bedrock. The deeper limestone bedrock may be three or more orders of magnitude lower in hydraulic conductivity than either the overburden or the shallow, solution enhanced bedrock. The lack of secondary porosity features at depth is the likely explanation for the pronounced decrease in permeability with depth in the DU Impact Area. There is little to no transmission of groundwater within this deeper rock.

In addition, data were taken based on wells south of the firing line from the RI performed at the site. The hydraulic conductivity of the till ranges from 0.079 to 0.24 ft/day in the area south of the firing line, based on slug tests in wells (Rust E&I 1998, MWH 2002). Small-scale fractures and sand lenses within the till contribute to the higher hydraulic conductivity measured by the slug tests.

Slug and pump tests were completed on 51 wells located south of the firing line screened in the bedrock aquifer. The hydraulic conductivity of the bedrock aquifer computed from slug tests ranges from 0.048 to 1.66 ft/day (MWH 2002). The pumping test results indicate hydraulic conductivities ranging from 0.40 to 17.3 ft/day (MWH 2002) in the bedrock.

3.4.2.3 Groundwater Use

The groundwater under JPG generally is of poor quality and is not used for drinking purposes or for other purposes in any significant capacity. The drinking water at JPG is obtained from the city of Madison Municipal Supply Systems and the Canaan Deposits in the Ohio River Valley, approximately 5 mi (8 km) from JPG (MWH 2002). Seven test holes drilled into the carbonate bedrock during initial development of the installation were unable to locate groundwater in sufficient quantities to support facility operations.

There are no sole source aquifers on or in the vicinity of JPG based on a review of sole source aquifer designations by USEPA Region 5. A sole source aquifer is an aquifer designated by USEPA as the sole, or principal, source of drinking water for a given area (i.e., an aquifer that supplies 50 percent or more of the area), and for which there is no reasonable alternative should the aquifer become contaminated.

3.4.2.4 Offsite Groundwater Wells

Table 3-5 lists the 31 groundwater wells drilled onsite and offsite within 5 mi of JPG that were drilled from 1941 to 1986 for domestic and stock use. The table and Figure 3-8 summarize the groundwater wells identified by an online search of the Indiana Department of Natural Resources (IDNR) well data files (see http://www.in.gov/dnr/water/2457.htm). The operational status of most of these wells is unknown. Six of the wells are located on JPG property (two north and four south of the firing line) but none are operational. Eleven wells are located to the west of (downgradient from) JPG and four wells are located east (upgradient) of JPG.

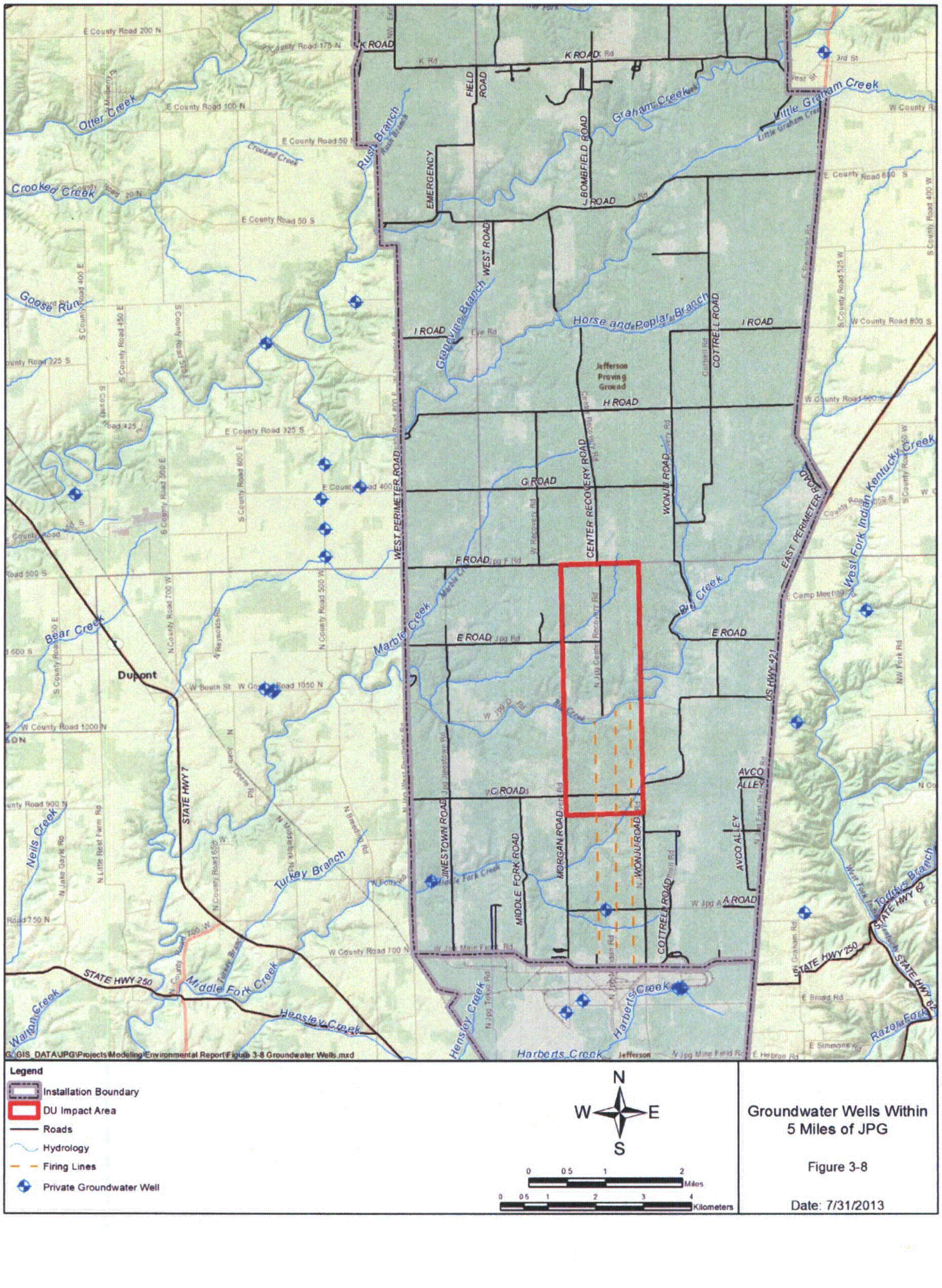
3.5 ECOLOGICAL RESOURCES

In this section, characteristics of wetlands (Section 3.5.1), plants (Section 3.5.2), and wildlife (Section 3.5.3) at JPG are described. Information is derived from numerous sources, including FWS (1994, 2001a-e, 2002, 2006, 2010b, 2012, and 2013), INANG (2013), IDNR (1993; 1999; 2010a,b; and

Table 3-5. Groundwater Wells Within 5 Miles of DU Impact Area
Jefferson Proving Ground, Madison, Indiana

x (meters)	y (meters)	z (ft AMSL)	Depth	Completion Date	x (meters)	y (meters)	z (ft AMSL)	Depth	Completion Date
638320	4298268	266.19376	72	15-Jan-41	640581	4299765	280.72459	80	27-Jan-65
640421	4296151	277.84962	81	27-Jul-57	629830	4298920	242.91905	78	28-Jan-66
641622	4300967	267.92474	80	23-May-60	642923	4307337	262.84980	100	27-Apr-66
630460	4305627	250.40096	85	24-Oct-60	632306	4309924	256.99188	60	24-Oct-66
630309	4305685	250.23196	80	2-Nov-60	631559	4310395	253.90491	87	18-Nov-66
630954	4302241	250.65295	60	14-Dec-60	632207	4313837	257.34587	125	28-Aug-76
643342	4297233	253.70692	100	20-Aug-62	637494	4298442	264.84978	200	6-Sep-78
641186	4299779	276.58564	70	1-Jan-63	637591	4298399	261.40882	200	6-Sep-78
640415	4297139	278.74061	65	18-Sep-63	639047	4299381	266.57176	200	8-Sep-78
630975	4309775	257.86086	125	12-Dec-63	638967	4299387	266.81776	200	11-Sep-78
631562	4309033	257.05887	100	17-Jan-64	636976	4299125	265.84977	200	13-Sep-78
631572	4308461	252.52693	80	18-Feb-64	637524	4298215	259.11285	200	6-Oct-78
642067	4300005	262.53981	80	5-Aug-64	633801	4301608	242.51405	200	9-Oct-78
641464	4300385	263.34580	54	17-Aug-64	641461	4304983	252.95892	150	25-Jun-86
641637	4299082	263.54080	60	12-Sep-64	636629	4298880	265.78677	98	
642292	4298554	252.41393	50	22-Sep-64					

Map Projection Information: North American Datum (NAD) 1927, Universal Transverse Mercator (UTM) Zone 16N.
Information from the Indiana State Water Well database: http://www.in.gov/dnr/water/2457.htm.



Groundwater Wells Within 5 Miles of JPG

Figure 3-8

Date: 7/31/2013

2012), Science Applications International Corporation (SAIC) (1997), and Montgomery Watson Harza (MWH) (2002). FWS announced in January 2013 the start of the process to update the Comprehensive Conservation Plan (CCP); however, the updated CCP will not be available for a few years.

3.5.1 Wetlands

The current estimate of wetland acreage on JPG is 6,240 ac (25.2 km^2). Of these wetlands, there are 670 ac (2.7 km^2) located on the DU Impact Area based on maps published by FWS. Within the DU Impact Area, the wetlands are located predominantly south of Big Creek (see Figure 3-9).

Most of the wetlands on JPG are classified as palustrine forested lands, which are dominated by woody vegetation 20 ft (6 m) high or taller. The wetlands within the DU Impact Area are classified as palustrine scrub-shrub dominated by broadleaf, scrub-shrub, with woody vegetation less than 20 ft (6.1 m) high. Riverine upper perennial wetlands are located along sections of Big Creek (FWS 2010b).

3.5.2 Plants

The JPG vegetation habitat types were derived from 1995 and 1997 aerial photographs and photo interpretation completed in 1998 (FWS 2006). Upland forests make up 27,600 ac (112 km^2) or 54 percent of the JPG acreage (see Figure 3-10). The primary evergreen species at JPG is eastern red cedar (*Juniperus virginiana*). Dominant deciduous trees include sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and black gum (*Nyssa sylvatica*) on poorly drained upland depression sites. Tulip poplar (*Liriodendron tulipifera*) and white ash (*Fraxinus americana*) are the species making up a majority of the young upland forests on well-drained sites. White oak (*Quercus alba*), red oak (*Quercus rubra*), and shagbark hickory (*Carya ovata*) are the dominant species on intermediate and some mature upland forests. American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) dominate the remainder of the mature upland forests (FWS 2006).

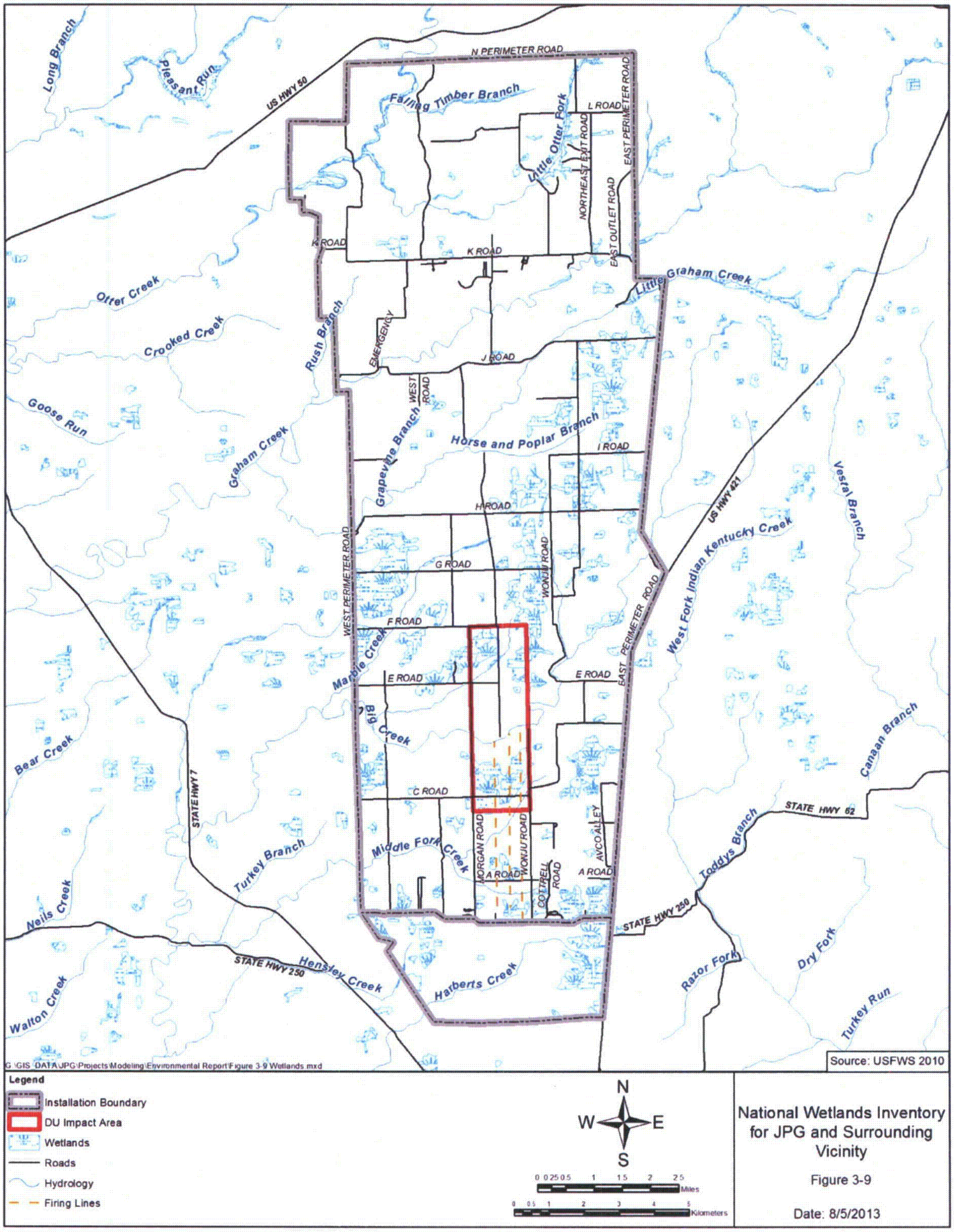
The second most abundant habitat at the JPG is grasslands. This habitat type comprises 9,000 ac (36.3 km^2 or 17 percent). The dominant grassland species appears to be broom sedge (*Andropogon* sp.) (FWS 2006).

Other habitat types at JPG include 5,300 ac (22 km^2 or 10 percent) of palustrine wetland, 3,200 ac (12.2 km^2 or 6 percent) of woodland, 6,200 ac (25 km^2 or 12 percent) of early successional habitat, and 300 ac (1.2 km^2) of open water and bare soil areas. Woodland species composition is comparable to that of upland forest. The palustrine wetland category includes all growth stages of palustrine vegetation, including early successional and forested wetland (FWS 2006).

Inventories of special plants were conducted by the IDNR Division of Nature Preserves in 1992 and 1998 (FWS 2013). The plant inventory conducted in 1992 identified 65 species of vascular plants listed as endangered, threatened, or rare, or that were on the State of Indiana's watch list (IDNR 1993). The 1998 plant inventory identified 46 species of vascular plants that are designated as endangered, threatened, rare, or on the State of Indiana's watch list species (INDR 1999). These plants and their current listing status are presented in Table 3-6. No federally listed plants were found (IDNR 1999); however, it was noted that excellent habitat was present in JPG for the federally endangered running buffalo clover (*Trifolium stoloniferum*). An inventory of the DU Impact Area was not conducted during the 1992 or 1998 surveys. Therefore, the occurrence of endangered plants within the DU Impact Area is unknown. An additional reference (MWH 2002) included inventories of observed and potential plant species within JPG; however, the probable locations of these species within the facility are also not discussed in the reference.

3.5.3 Wildlife

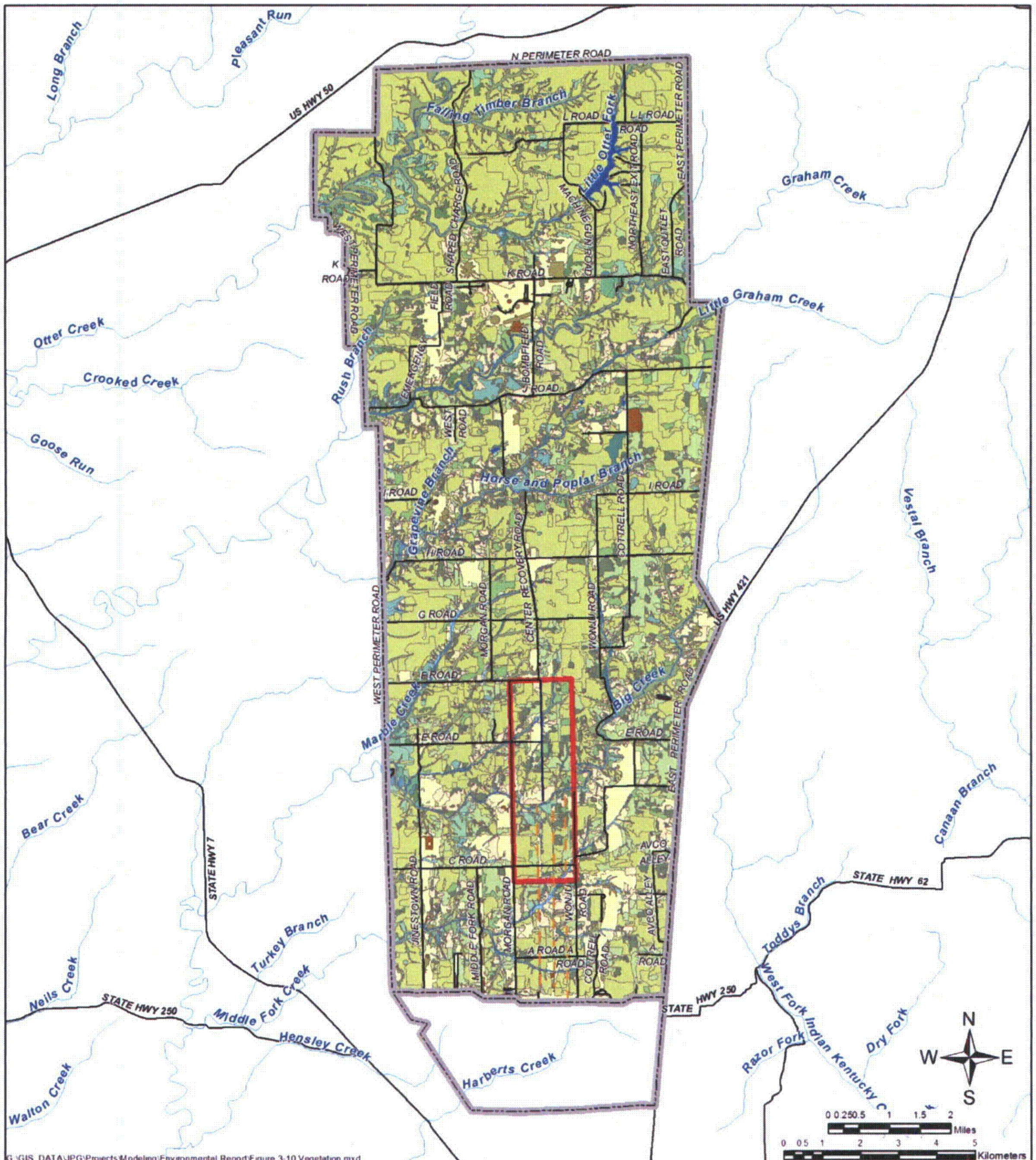
JPG provides quality habitat for a variety of terrestrial and aquatic species. Forty-six species of mammals, 41 species of fish, 8 species of freshwater mussels, 24 species of amphibians, and 18 species of reptiles have been found on the installation (FWS 2013). Mammal species include white-tail deer,



National Wetlands Inventory for JPG and Surrounding Vicinity

Figure 3-9

Date: 8/5/2013



Vegetation Classes at Big Oaks NWR

Figure 3-10

Date: 8/5/2013

Table 3-6. State of Indiana Endangered, Threatened, Rare, and Watch List Vascular Plants Documented From JPG
Jefferson Proving Ground, Madison, Indiana

Species Name	Common Name	Current Status
Crotonopsis elliptica	Elliptical rushfoil	E
Helianthus angustifolius	Narrow-leaved sunflower	E
Hypericum gymnanthum	Clasping St. John's wort	E
Lycopodeiella inundata	Northern bog clubmoss	E
Lygodium palmatum	Climbing fern	E
Panicum scoparium	Broom panic-grass	E
Najas gracillima	Thread-like naiad	T
Rhexia mariana var. mariana	Maryland meadow beauty	T
Strophostyles leiosperma	Slick seed wild-bean	T
Asplenium ruta-muraria	Wall-rue spleenwort	R
Lycopodium obscurum	Tree clubmoss	R
Oenothera perennis	Small sundrops	R
Poa wolfii	Wolf bluegrass	R
Sagittaria autralis	Longbeak arrowhead	R
Scirpus purshianus	Weakstalk bulrush	R
Waldsteinia fragarioides	Barren strawberry	R
Woodwardia areolata	Nettled chain-fern	R
Aesculus octandra	Yellow buckeye	WL
Agalinis fasciculata	Clustered foxglove	WL
Andropogon ternarius	Silver bluestem	WL
*Antennaria solitaria**	Single-headed pussytoes	WL
Bartonia paniculata	Twining bartonia	WL
Botrychium biternatum	Sparse-lobe grape fern	WL
Botrychium oneidense	Blunt-lobe grape fern	WL
Carex abscondita	Thicket sedge	WL
Carex louisianica	Louisiana sedge	WL
Carex woodii	Pretty sedge	WL
Chimaphila maculata	Spotted wintergreen	WL
Cimicifuga racemosa	Black bugbane	WL
Dentaria diphylla	Crinkleroot	WL
Eupatorium rotundifolium	Round-leaved boneset	WL
Hydrastis canadensis	Goldenseal	WL
Linum striatum	Ridged yellow flax	WL
Lycopodium clavatum	Running pine	WL
Monotropa hypopithes	American pinesap	WL
Oxalis illinoensis	Illinois woodsorrel	WL
Panax quinquefolium	American ginseng	WL
Panax trifolium	Dwarf ginseng	WL
Platanthera lacera	Green-fringed orchid	WL
Platanthera peramoena	Purple fringeless orchid	WL
Salix caroliniana	Carolina willow	WL
Scleria pauciflora	Fewflower nutrush	WL
Spiranthes ovalis	Lesser ladies'-tresses	WL
Spiranthes tuberosa	Little ladies'-tresses	WL
Veratrum woodii	False hellebore	WL
Viola blanda	Smooth white violet	WL

Plant Source: IDNR 1999 (based on 1992 and 1998 field surveys)
Notes:
*Tentative identification
E = State of Indiana Endangered (IDNR 2010a,b)
R = State of Indiana Rare (IDNR 2010a,b)
T = State of Indiana Threatened (IDNR 2010a,b)
WL = State of Indiana Watch List (IDNR 2010a,b)
No federally threatened or endangered species were found during the surveys.

raccoon, coyote, opossum, gray and fox squirrel, skunk, beaver, red fox, weasel, and mink. Large populations of small mammals, including mice and moles, attract significant numbers of reptiles and raptors. JPG is approximately 80 percent reforested, and the unbroken stands of mature and young trees are used by migrating neo-tropical birds. More than 200 species of birds have been observed at Big Oaks with 120 of those observed nesting (FWS 2013). The American Bird Conservancy listed the Big Oaks NWR as a Globally Important Bird Area in 1998 because of its importance to grassland birds (e.g., Henslow's sparrow) and forest birds (e.g., Cerulean warbler). FWS and the Institute for Bird Populations are conducting ongoing census surveys of wildlife at the installation. Twenty-five river otters were released in February 1996 at the Old Timbers Lake in support of Indiana's Otter Restoration Program (SAIC 1997). An additional six otters (four male and two female) were released in 1999 to supplement the population (BOCS 2003). Another semi-aquatic species of interest at JPG is the beaver, which can influence hydrology, wetlands, and vegetation across large areas. They also have the ability to negatively impact roads and stream crossings. The Big Oaks NWR actively manages to minimize infrastructure impacts but otherwise allows beavers to create new impoundments, and this is increasing the area of permanent water and wetland diversity on the Big Oaks NWR (INANG 2013).

JPG provides habitat for a wide variety of game animals and fish that are harvested on the installation. Hunting is allowed on approximately 27,700 ac (112 km^2). The remaining area, approximately 27,300 ac (110 km^2), provides habitat for small game; however, this land is closed to hunters because of the presence and hazards of UXO and DU. The staff of the Big Oaks NWR manage the hunting program at JPG (FWS 2013).

Squirrel (eastern gray and fox), white-tailed deer, and wild turkey hunting is permitted in designated areas administered by FWS as part of the Big Oaks NWR (FWS 2013). The deer harvest has ranged from 356 to 805 deer in recent years; typically 400 to 500 whitetail deer are harvested annually (BOCS 2012). The wild turkey harvest averages 50 birds per year (MWH 2002). Permit drawn hunts for the general public have been conducted for deer since the 1960s and for turkey since 1984. Fishing is only permitted at the 165-ac (0.67-km) Old Timbers Lake. The last fish survey was conducted at Old Timbers Lake in 2001 (FWS 2013). Bass, bluegill, sunfish, and crappie were collected during the survey (FWS 2002).

There are six federally endangered animals (two birds, one mammal, and three mollusks) that may occur within the boundaries of JPG. Two federally endangered bird species (Piping plover [*Charadrius melodus*] and Kirtland's warbler [*Dendroica kirtlandi*]) are transients that may be present during migration; however, these species have not been recorded at JPG (FWS 2012). The Indiana bat (*Myotis sodalis*) has been documented at JPG (Rust E&I 1998). Three federally endangered mollusk species (Snuffbox [*Eioblasm triqetra*], Sheepnose [*Plethobasus cyphyus*], and Clubshell [*Pleurobema clava*]) are potentially present but have not been documented at JPG (INANG 2013). One federally threatened snake (Copper-bellied watersnake [*Nerodia erythrogaster*]) may occur within the boundaries of JPG but has never been recorded there. Ten bird species have been documented at JPG that are listed as USEPA Region 3 Federal species of concern (INANG 2013). Table 3-7 identifies Federal and State of Indiana endangered and threatened species and species of special concern.

In addition to the 7 federally threatened and endangered species listed above, which also have State of Indiana threatened or endangered species status, 29 additional State of Indiana-endangered species (1 mammal, 17 birds, 2 amphibians, 1 reptile, 3 crustaceans, 2 butterflies, 2 arachnids, and 1 millipede) and 4 State of Indiana-threatened species (1 bird, 1 butterfly, 1 crustacean, and 1 springtail) also have been identified as potentially occurring at JPG. Fifteen of these species (13 birds, 1 amphibian, and 1 reptile) have been documented at JPG. The Henslow's sparrow (*Ammodramus henslowii*) has been identified as a breeding species at JPG. An additional 19 species potentially present at JPG (5 mammals, 7 birds, 2 amphibians, and 5 mollusks) are listed as Indiana species of special concern (INANG 2013).

Table 3-7. Federal and State Endangered and Threatened Species and Species of Special Concern Jefferson Proving Ground, Madison, Indiana

Species Type	Species Name	Common Name	Current Status
Mammal	*Myotis sodalis*	Indiana bat*	FE, INE
Mammal	*Nycticeius humeralis*	Evening bat	INE
Mammal	*Lutra canadensis*	River otter*	INSC
Mammal	*Lynx rufus*	Bobcat*	INSC
Mammal	*Mustela nivalis*	Least weasel	INSC
Mammal	*Sorex fumeus*	Smoky shrew	INSC
Mammal	*Taxidea taxus*	American badger	INSC
Bird	*Charadrius melodus*	Piping plover	FE, INE
Bird	*Dendroica kirtlandii*	Kirtland's warbler	FE, INE
Bird	*Ammodramus henslowii*	Henslow's sparrow*	FSC, INE
Bird	*Asio flammeus*	Short-eared owl*	INE
Bird	*Botaurus lentiginosus*	American Bittern*	INE
Bird	*Circus cyaneus*	Northern harrier*	INE
Bird	*Cistothorus palustris*	Marsh Wren*	INE
Bird	*Cistothorus platensis*	Sedge wren*	FSC, INE
Bird	*Dendroica cerulea*	Cerulean warbler*	FSC, INE
Bird	*Falco peregrinus*	Peregrine falcon	INE
Bird	*Grus canadensis*	Sandhill Crane	INT
Bird	*Ixobrychus exilis*	Least Bittern*	INE
Bird	*Lanius ludovicianus migrans*	Loggerhead shrike*	FSC, INE
Bird	*Nyctanassa violacea*	Yellow-crowned Night Heron	INE
Bird	*Nycticorax nycticorax*	Black-crowned Night-Heron*	INE
Bird	*Pandion haliaetus*	Osprey*	INE
Bird	*Rallus elegans*	King Rail	INE
Bird	*Rallus limicola*	Virginia Rail*	INE
Bird	*Tyto alba*	Barn owl	INE
Bird	*Vermivora chrysoptera*	Golden-winged Warbler*	INE
Bird	*Accipiter striatus*	Sharp-shinned hawk*	INSC
Bird	*Ammodramus savannarum*	Grasshopper sparrow*	FSC
Bird	*Ardea alba*	Great Egret*	INSC
Bird	*Buteo lineatus*	Red-shouldered hawk*	FSC, INSC
Bird	*Buteo platypterus*	Broad-winged hawk*	INSC
Bird	*Dolichonyx oryzivorous*	Bobolink	FSC
Bird	*Haliaeetus leucocephalus*	Bald Eagle*	INSC
Bird	*Helmitheros vermivorus*	Worm-eating warbler*	INSC
Bird	*Mniotilta varia*	Black-and-white warbler*	INSC
Bird	*Scolopax minor*	American woodcock	FSC
Bird	*Spiza americana*	Dickcissel*	FSC
Bird	*Sturnella magna*	Eastern Meadowlark*	FSC
Bird	*Wilsonia citrina*	Hooded Warbler*	INSC
Amphibian	*Cryptobranchus alleganiensis*	Hellbender	INE
Amphibian	*Lithobates areolatus*	Crawfish Frog*	INE
Amphibian	*Hemidactylum scutatum*	Four-toed Salamander*	INSC
Amphibian	*Necturus maculosus*	Common Mudpuppy*	INSC
Reptile	*Nerodia erythrogaster*	Copper-bellied Watersnake	FT, INE
Reptile	*Clonophis kirtlandii*	Kirtland's snake*	INE
Mollusk	*Epioblasma triquetra*	Snuffbox	FE, INE
Mollusk	*Plethobasus cyphyus*	Sheepnose	FE, INE
Mollusk	*Pleurobema clava*	Clubshell	FE, INE
Mollusk	*Obovaria subrotunda*	Round Hickorynut	INSC
Mollusk	*Pleurobema cordatum*	Ohio pigtoe	INSC
Mollusk	*Simpsonaias ambigua*	Salamander Mussel*	INSC
Mollusk	*Toxolasma lividus*	Purple Lilliput	INSC
Mollusk	*Villosa lienosa*	Little Spectaclecase*	INSC
Arachnids	*Porhomma cavernicola*	Appalachian cave spider	INE

Table 3-7. Federal and State Endangered and Threatened Species and Species of Special Concern Jefferson Proving Ground, Madison, Indiana (Continued)

Species Type	Species Name	Common Name	Current Status
Arachnids	*Chthonius virginicus*	Pseudoscorpion	INE
Butterflies	*Atrytonopsis hianna*	Dusted Skipper	INT
Butterflies	*Erynnis martialis*	Mottled Duskywing	INE
Butterflies	*Speyeria idalia*	Regal Fritillary	INE
Crustaceans	*Crangonyx anomalus*	Anomalous Spring Amphipod	INT
Crustaceans	*Diacyclops indianensis*	Indiana Groundwater Copepod	INE
Crustaceans	*Diacyclops lewisi*	Lewis' Groundwater Copepod	INE
Crustaceans	*Diacyclops salisae*	Salisa's Groundwater Copepod	INE
Millipede	*Pseudopolydesmus collinus*	A Millepede	INE
Springtails	*Pseudosinella fonsa*	Fountain cave springtails	INT

Sources: IDNR (2012) and INANG (2013)
* = These species have been documented at JPG
FE = Federally Endangered
FT = Federally Threatened
FSC = Federal Species of Concern; note this designation does not convey a legal protective status
INE = Indiana Endangered
INT = Indiana Threatened
INSC = Indiana Species of Special Concern; note this designation does not convey a legal protective status

3.6 METEOROLOGY, CLIMATOLOGY, AND AIR QUALITY

JPG lies within a temperate climate zone. Average annual precipitation is 47 in/y (119.4 cm) for the period 1976 through 2007 at Madison, Indiana (SAIC 2008a). During this same period, annual precipitation extremes ranged from a low of 33.2 in (84.3 cm) in 1987 to a high of 60.9 in (154.7 cm) in 1990. Average monthly precipitation ranges from a high of 5.08 in (12.9 cm) in May to a low of 2.8 in (7.1 cm) in February (Table 3-8). For comparison, the average annual precipitation from nearby Versailles, Indiana weather station for 57 years (1949 through 2005) is 43.1 in/y (109.5 cm/y), ranging from a low of 26.9 in (68.3 cm) in 1953 to a high of 60.2 in (153.9 cm) in 1990. Table 3-8 lists monthly temperatures and record extremes at Madison, Indiana. On average, July and August are the warmest months, and January is the coldest month.

Table 3-8. Monthly Precipitation and Temperature at Madison, Indiana Jefferson Proving Ground, Madison, Indiana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Precipitation (in) for Madison, IN (1976-2007)												
Average	3.41	2.80	3.87	4.18	5.08	4.18	4.61	4.36	3.08	3.67	3.93	3.81
Min	0.52	0.22	1.04	0.88	1.31	0.34	0.94	1.16	0.24	0.83	0.94	0.50
Max	8.21	7.82	7.80	8.22	11.63	9.00	9.36	8.90	8.22	12.30	7.39	7.93
Monthly Temperature (°F) source: http://www.weather.com/weather/wxclimatology/monthly/USIN0386												
Average High	42	47	57	68	76	85	88	88	81	70	58	46
Average Low	23	25	32	42	53	62	66	65	57	45	35	27
Mean	33	36	45	55	65	74	77	77	69	58	47	37
Record High	75 (1950)	76 (2000)	84 (1981)	93 (1957)	97 (1953)	103 (1988)	108 (1954)	104 (1988)	108 (1953)	96 (1953)	88 (1950)	77 (1982)
Record Low	-17 (1994)	-12 (1951)	-2 (1980)	10 (2007)	27 (1963)	37 (1966)	48 (1972)	43 (1986)	33 (1995)	23 (1981)	0 (1950)	-18 (1989)

There are five weather stations located in close proximity to JPG, three of which are active, that collect limited data (e.g., minimum/maximum temperature, precipitation) and may be accessed from the National Climatic Data Center (NCDC) (see http://www.ncdc.noaa.gov/). Weather stations (Figure 3-11) located in close proximity to JPG collected data over various periods: Butlerville 1 WNW (station ID 121192) collected data from 1 November 1983 to 17 February 2000, Butlerville 2 WNW (station ID 121197) collected data from 1 July 1948 to 30 June 1957, North Vernon 2 ESE (station ID 126435) collected data from 1 April 1948 to the present, and North Vernon 2 NE (station ID 126437) collected data from 1 December 1997 to the present. An FWS weather station (BIGI3) exists at JPG off East Perimeter Road 2.5 mi to the northeast of the DU Impact Area near the intersection of Route 421 and Old Michigan Road. Data collection began at this station in 2003 (see http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=MBIGI3).

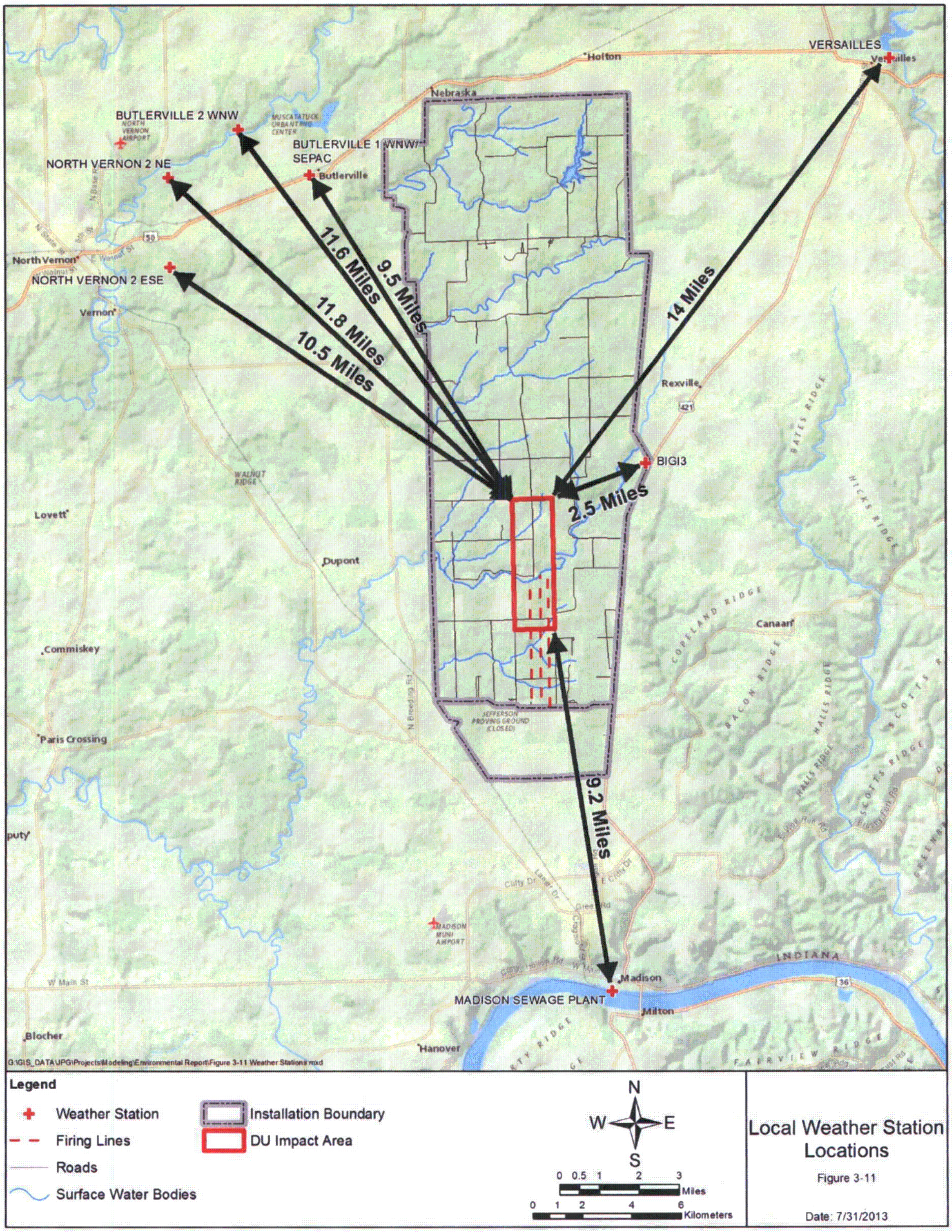
Wind speed and direction data may be obtained from Indianapolis, Indiana (USEPA site numbers 18-097-0073 and 18-097-0084); Mechanicsburg, Indiana (USEPA site number 18-065-0003); and Charlestown State Park, Indiana (USEPA site number 18-019-0008) (see http://www.in.gov/idem/airquality/2390.htm).

The Indiana State Climate Office (see https://climate.agry.purdue.edu/climate/index.asp) archives official daily and hourly weather observations from the following stations: West Lafayette (Station ID ACRE), Davis Purdue Agricultural Center (PAC)-Farmland (Station ID DPAC), Northeast PAC-Columbia City (Station ID NEPAC), Pinney PAC-Wanatah (Station ID PPAC), Southeast PAC-Butlerville (Station ID SEPAC), Southwest PAC-Vincennes (Station ID SWPAC), and Throckmorton PAC-Lafayette (Station ID TPAC). All available wind speed and gust data (July 2002 to July 2013) from the station located in Butlerville, which is the closest to the DU Impact Area, are listed in Table 3-9.

The following four inactive air monitoring stations are located in Jefferson County (see http://www.epa.gov/airdata/ad_maps.html searched using zip code 47250):

- Bacon Ridge Road (Air Quality System [AQS] Site ID: 18-077-0001) that monitored for sulfur dioxide from 13 February 1974 to 30 September 1995
- Graham Road (AQS Site ID: 18-077-0002) that monitored for sulfur dioxide from 13 February 1974 to 30 September 1995
- K Road (AQS Site ID: 18-077-0003) that monitored for sulfur dioxide from 13 February 1974 to 30 September 1995
- Wilson Avenue (AQS Site ID: 18-077-0004) that monitored for sulfur dioxide from 12 February 1974 to 30 June 1995.

Since none of the stations in the vicinity of JPG is active, a review of state-level data is provided herein. The State of Indiana's ambient air quality standards are identical to the National Ambient Air Quality Standards (NAAQS). Air quality monitoring is conducted under the Indiana Department of Environmental Management's (IDEM's) Office of Air Management. During operation, JPG was not classified as a major source contributor to air pollution (U.S. Army 1995a). No emission sources are associated with the DU Impact Area. Although there are no active monitoring stations near JPG, none of the maximum air quality statistics for any counties in Indiana exceeded state or Federal ambient air quality standards for samples collected from 2008 through 2012 and sample results available for 2013 for any of the following six criteria pollutants (see http://www.epa.gov/airdata/ad_rep_con.html): carbon monoxide (second highest 1-hour measurement in year and second highest nonoverlapping 8-hour average in year), nitrogen dioxide (98^{th} percentile of daily maximum 1-hour measurements in year), ozone (second highest daily maximum 1-hour measurement in year and fourth highest daily maximum 8-hour average in year), sulfur dioxide (99^{th} percentile of the daily maximum 1-hour measurements in year and second highest 24-hour average measurement in year), particulate matter smaller than 2.5 micrometers



Local Weather Station Locations

Figure 3-11

Date: 7/31/2013

Table 3-9. Monthly Wind Speed and Gust Data for Butlerville, Indiana Jefferson Proving Ground, Madison, Indiana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph) for Butlerville, IN (2007-2013)												
Average	5.9	5.5	6.1	6.3	4.8	4.0	2.9	2.6	3.1	4.4	5.3	5.8
Min	0	0	2	0	0	0	0	0	0	0	0	0
Max	13	14	13	14	13	9.0	8.0	7.0	10	13	12	15
Wind Gust (mph) for Butlerville, IN (2007-2013)												
Average	20	20	22	24	21	19	16	15	16	19	20	20
Min	0	0	6.0	0	0	0	0	0	2.0	8.0	0	0
Max	52	45	49	49	54	60	54	44	58	44	47	52
Direction (°)	213	204	191	199	194	199	188	191	175	203	201	208

($PM_{2.5}$) (98^{th} percentile of daily average measurements in year and weighted annual mean [mean weighted by calendar quarter] for year), and particulate matter smaller than 10 micrometers (PM_{10}) (second highest 24-hour average measurement in year).

The JPG region also is subject to tornadoes, which are most common in southeastern Indiana from May through July. The NCDC in Asheville, North Carolina compiled a storm events data base with statistics for tornadoes striking the contiguous United States from 1 January 1950 through 31 August 2003 and contains entries for 46,864 tornado segments, which is a portion or all of a tornado. The U.S. Nuclear Regulatory Commission (NRC) (2007) used the reported characteristics in the data base to estimate tornado strike probabilities and requirements for use in designing structures (e.g., nuclear power plants). Based on a geographical distribution of tornado events in the United States, NRC (2007) estimates 113 tornado events occurred within 1° of latitude (38.889362) and longitude (-85.416023) of the center of the DU Impact Area between the beginning of 1950 and the end of August 2003. Of these, NRC estimates 63 of those tornado events occurred with intensities of F2 or greater and 15 occurred with intensities of F4 or greater.

A tornado occurred at JPG in 1998. The tornado path traversed the area north of the firing line, entering the installation north of F Road and exiting the installation at approximately H Road. If the tornado followed a straight path, it would have touched down approximately 2.5 mi (4 km) north of the DU Impact Area. According to NCDC, for the period from 1950 to 1995, an annual average of 20 tornadoes per year occurred in the State of Indiana. An additional 18 tornadoes occurred in Jefferson, Jennings, and Ripley Counties from 1996 to 2013, as shown in Table 3-10 as listed in the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database for Indiana (data available from January 1996 to March 2013) (http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=18%2CINDIANA). In addition to the tornados listed in Table 3-10, an F4 or F5 (depending on the referenced source) struck the city of Madison in Jefferson County on 3 April 1974 at 2:19 p.m., killing nine people immediately and a tenth person within the month and injuring (hospitalizing) almost 200 people (http://www.mjcpl.org/historyrescue/timeline/1974-tornado).

3.7 NOISE

Prior to closure in 1995, JPG conducted operations in accordance with an Installation Compatible Use Zone program based on a 1983 environmental noise assessment to quantify major noise sources. However, since the cessation of JPG's firing mission in September 1994, impulse noise impacts beyond the base boundaries have been eliminated. There is no noise generated in the DU Impact Area and there are no activities in the cantonment area that would generate noise above acceptable levels.

Table 3-10. Summary of Tornadoes in Jefferson, Jennings, and Ripley Counties (1996-2013) Jefferson Proving Ground, Madison, Indiana

Location	County	Date	Time	Magnitude[a,b]	Direct Deaths from Event	Direct Injuries from Event	Property Damage Estimate	Crop Damage Estimate
Blocher	Jefferson	3/28/1997	20:47	F1	0	0	200.00K	0.00K
Dupont	Jefferson	4/9/1999	2:56	F2	0	0	100.00K	0.00K
Deputy	Jefferson	8/14/2002	13:52	F1	0	0	100.00K	0.00K
Deputy	Jefferson	4/19/2011	23:25	EF0	0	0	0.00K	0.00K
China	Jefferson	4/19/2011	23:40	EF1	0	0	0.00K	0.00K
Bryantsburg	Jefferson	4/19/2011	23:41	EF0	0	0	0.00K	0.00K
Smyrna	Jefferson	1/17/2012	10:40	EF0	0	0	40.00K	0.00K
Chelsea	Jefferson	3/2/2012	15:26	EF4	4	0	750.00K	0.00K
San Jacinto	Jennings	4/9/1999	3:00	F3	0	0	250.00K	0.00K
North Vernon	Jennings	6/12/2005	17:35	F1	0	0	100.00K	0.00K
San Jacinto	Jennings	8/14/2006	18:59	F0	0	0	10.00K	0.00K
North Vernon	Jennings	5/15/2007	20:35	EF0	0	0	100.00K	0.00K
Hayden	Jennings	9/25/2011	23:33	EF1	0	0	65.00K	2.00K
Rexville	Ripley	4/9/1999	3:05	F3	0	2	1.400M	0.00K
Holton	Ripley	7/30/2004	19:17	F2	0	2	465.00K	0.00K
Sunman	Ripley	3/8/2009	16:22	EF1	0	0	40.00K	0.00K
Sunman	Ripley	5/23/2011	17:43	EF0	0	0	5.00K	0.00K
Holton	Ripley	3/2/2012	15:52	EF3	2	6	275.00K	0.00K

[a] Tornado magnitudes Fujita (F) scale: F0 (Gale), F1 (Weak), F2 (Strong), F3 (Severe), F4 (Devastating), and F5 (Incredible).
[b] Tornado magnitudes operational Enhanced Fujita (EF) scale: EF0 (65-85 mph 3-second gust), F1 (86-110 mph 3-second gust), F2 (111-135 mph 3-second gust), F3 (136-165 mph 3-second gust), F4 (166-200 mph 3-second gust), and F5 (over 200 mph 3-second gust) (http://www.spc.noaa.gov/efscale/ef-scale.html).

The only remaining noise zone identified at JPG is for aircraft conducting air-to-ground gunnery training at a range located in the northwestern section of the installation. The Jefferson Range activities involve training munitions (i.e., inert munitions with spotting charges) and sometimes laser energy (U.S. Army 2000a). Live munitions with high or low explosive warheads are not allowed. Thus, much of the noise associated with Jefferson Range is from aircraft traveling through one of the restricted airspaces over and near the range (INANG 2010): JPG Military Operations Areas A, B, C, and D; Ripley Air Traffic Control Association Area (ATCAA); and Restricted Areas R3403A/B. Normal operating hours are Monday through Friday, with one or two weekends per month depending on requests. Flying periods occur either in the morning, evening, or at night and Jefferson Range typically receives requests to fly morning, afternoon, and night for a 16-hour day. However, manpower resources force the schedule to satisfy only two of the requested periods. Jefferson Range currently supports eight Air National Guard (ANG) units and some regular users from the Army National Guard (ARNG), USAF, and U.S. Marine Corps (USMC). Approximately 900 sorties occur per year at Jefferson Range, with increasing ground operations (ANG 2001). The Military Operations Areas "caps" total yearly utilization at 3,000 sorties due to environmental concerns (U.S. Army 2000a). Typically, 90 to 120 decibels are generated by INANG's air-to-ground gunnery range operations (less than 65 decibels is considered an acceptable level of noise). Noise complaints to the Range Operational Center are infrequent, averaging no more than one complaint per year (INANG 2010). All complaints are reviewed to ensure that aircrews are compliant with local regulations.

3.8 HISTORICAL AND CULTURAL RESOURCES

Cultural resources at JPG have been investigated as part of either archaeological overviews or previous archaeological surveys. A total of 153 sites have been recorded in 4,872 surveyed ac (19.7 km^2) (Geo-Marine 1996). The majority of the identified sites are located in the cantonment area, located south of the firing line. Much of the installation, particularly the area north of the firing line (including the DU

Impact Area), has had limited access and development during the last 50 years. However, because of its use as a proving ground, there has been loss of potential archaeological sites (Geo-Marine 1996).

A cultural resources sensitivity model was developed for the installation that excludes a total area of 33,645 ac (136 km^2) of the site because either the land has been previously disturbed by construction, use, or maintenance of the facility, or the areas have been surveyed previously (U.S. Army 2002a). The DU Impact Area falls into the excluded area both because portions of the land area have been disturbed to a depth greater than 6 ft (1.8 m) BGS and because of the presence of UXO. Although a cultural resources survey has not been conducted at the DU Impact Area because of the UXO and DU hazards, 10 potential historic site locations were documented through research of historic maps and atlases between 1876 and 1921. These sites were determined to be in poor condition because of the extensive land disturbance and were determined to be ineligible for the National Register of Historic Places (NRHP) (Geo-Marine 1996).

In 1994, a survey for chert (i.e., a common tool stone in prehistoric lithic contexts throughout southern Indiana) was conducted along the banks of Big Creek up to the western border of the DU Impact Area. Two rockshelter archaeological sites (Mbutu et al. 1996, Hawkins and Walley 1995:IX-9) were found downstream from the DU Impact Area. The sites were not eligible for listing on the NRHP (Geo-Marine 1996).

Six structures at the installation (Figure 3-12) are listed on the NRHP, including the Oakdale School; Old Timbers Lodge; and four stone arch bridges over Otter Creek, Marble Creek, and Graham Creek (IDNR 1996). A photograph of the bridge crossing at Graham Creek is included in Figure 3-13. Old Timbers Lodge was constructed in 1931 and is listed on the NRHP. The four stone arch bridges were erected in 1908 or 1910 and are considered eligible for listing on the NRHP. The additional property for which INANG provides routine maintenance is the Oakdale Schoolhouse, which is owned by the Army. The Oakdale Schoolhouse, which dates to 1869, is listed on the NRHP. None of these sites are located within the DU Impact Area, as shown in Figure 3-12.

Cultural resources at JPG are protected under two separate agreements. The 1992 Amended BRAC Programmatic Agreement between the Department of the Army, Advisory Council on Historic Preservation (ACHP), and State Historic Preservation Office (SHPO) (Geo-Marine 1996, Appendix L) requires the Army to identify and evaluate historic properties, determine the effects of BRAC actions on historic properties, and take actions to ensure that the effects of BRAC actions on historic properties are in accordance with the agreements in the BRAC Programmatic Agreement. The MOA between the Army, ACHP, and Indiana SHPO (Geo-Marine 1996, Appendix M) stipulates that the Army implement a Cultural Resources Management Plan (CRMP), among other requirements. The CRMP provided guidelines and procedures to enable JPG to meet its legal responsibilities while under Army control for the identification, evaluation, and treatment of historic properties under its jurisdiction (Geo-Marine 1996).

After the Army's mission ended at JPG, INANG assumed responsibility for maintaining five historic properties located on JPG/Jefferson Range and has agreed to provide routine maintenance for an additional historic property at JPG. Pursuant to these responsibilities and in accordance with U.S. Department of Defense Instruction (DODI) 4715.3 (DOD 1996), Air Force Instruction 32-7065 (USAF 2004), and DODI 4715.16 (DOD 2008), INANG developed an Integrated Cultural Resources Management Plan (ICRMP) for the Jefferson Proving Ground/Jefferson Range (INANG 2011). It includes a cultural resources inventory, cultural resource management goals, Environmental Manager's (EM's) cultural resource guidance and procedures, and standard operating procedures (SOPs).

3.9 VISUAL/SCENIC RESOURCES

JPG is divided visually into the areas north and south of the former firing line. The area south of the firing line, or cantonment area, is a well-maintained area with buildings that formerly supported the

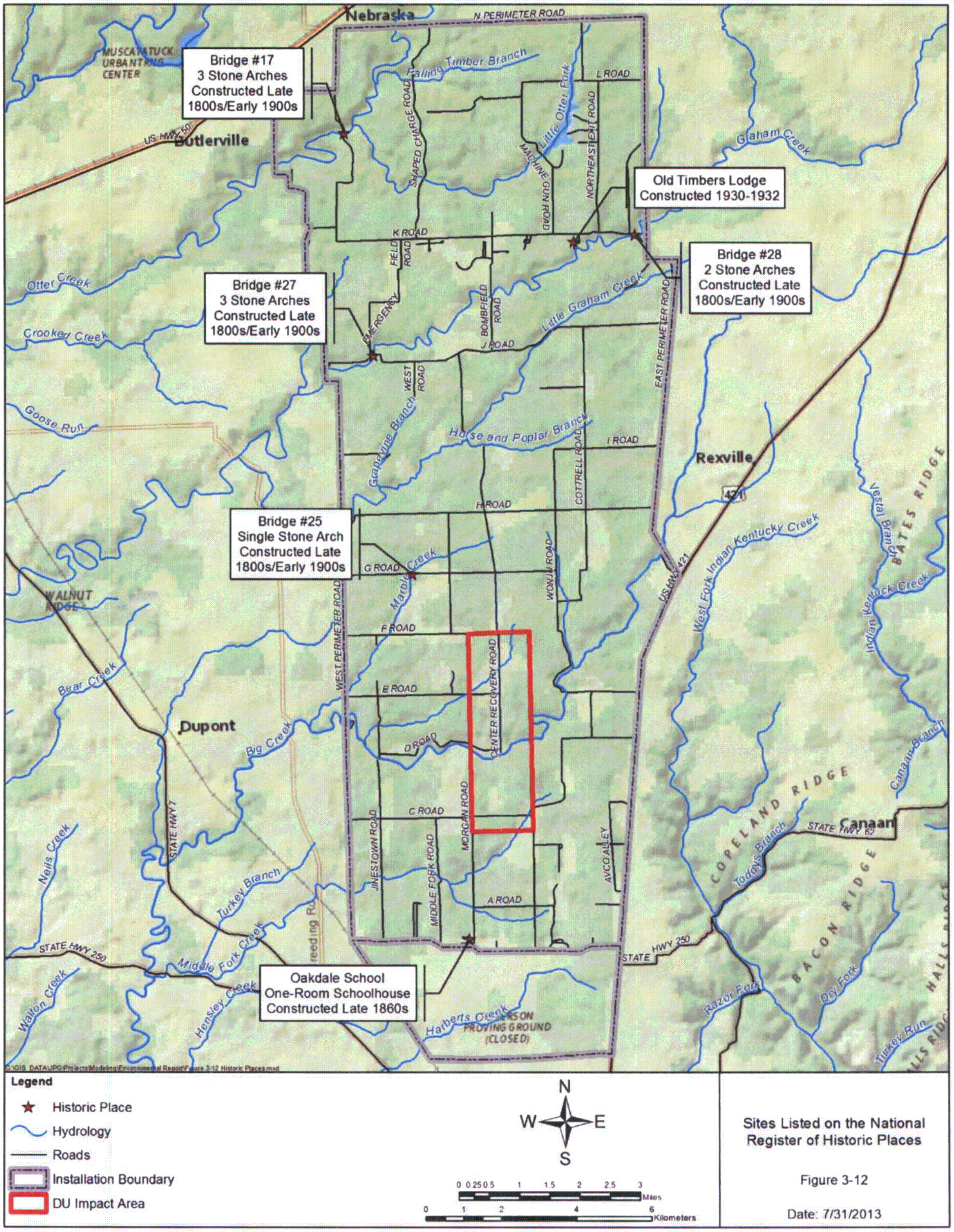

Bridge #17
3 Stone Arches
Constructed Late
1800s/Early 1900s
Old Timbers Lodge
Constructed 1930-1932
Bridge #28
2 Stone Arches
Constructed Late
1800s/Early 1900s
Bridge #27
3 Stone Arches
Constructed Late
1800s/Early 1900s
Bridge #25
Single Stone Arch
Constructed Late
1800s/Early 1900s
Oakdale School
One-Room Schoolhouse
Constructed Late 1860s
Nebraska
Butlerville
Rexville
Dupont
Canaan
N PERIMETER ROAD
EAST PERIMETER ROAD
WEST PERIMETER ROAD
CENTER RECOVERY ROAD
Legend
Historic Place
Hydrology
Roads
Installation Boundary
DU Impact Area
N
W
E
S
Miles
Kilometers
Sites Listed on the National
Register of Historic Places
Figure 3-12
Date: 7/31/2013

Figure 3-13. Bridge on J Road Crossing Graham Creek (Constructed 1908)

installation staff. The main gate entrance is flanked by well-manicured grounds and tree-lined, open spaces that provide a visually attractive entrance to the facility. The road to the administrative area is lined with mature maple trees. The buildings in these areas are predominantly wood structures. Operations and maintenance buildings are red brick and were heated by steam through an aboveground steam system when the facility was operational. Thirteen housing units are arranged along a tree-lined, elongated, horseshoe-shaped drive. Other visual resources include Krueger Lake, approximately 1,200 ft (366 m) long by 250 ft (76 m) wide. A closed airfield shown in Figure 3-14 occupies the southwestern area of the cantonment area. The remaining area includes woodlands and grassy areas. A dominant feature in this area is a water tower. With closure of this area in 1995, the property has been and is continuing to be transferred. Various parcels are under private or public ownership. Residential, light manufacturing operations, recreational, and farming are the current predominant land uses.

The area north of the firing line is characterized as heavily vegetated rolling hills, with some open spaces. The DU Impact Area and the INANG bombing range are located within this portion of JPG. In the northeast corner of the base is a 165-ac (0.67 km^2) lake (Old Timbers Lake) used for fishing (Figure 3-15).

Archaeological structures are present north of the former firing line and include six structures and four stone bridges (see Section 3.8). More than 55 mi (88 km) of chain-link fence topped with barbed wire surrounds the facility. The view of the facility from the fence line is obscured primarily by trees 30 to 50 ft (9 to 15 m) tall with thin undergrowth. Occasional open spaces around the fence line permit views of up to several hundred yards.

Figure 3-14. Aerial Photograph of Former JPG Airfield Runways (4 July 1970)

Figure 3-15. Aerial Photograph of Old Timbers Lake

The Bureau of Land Management (BLM) Visual Resource Inventory and Evaluation System rating for the DU Impact Area is Class I. The rating for the cantonment area is Class IV (U.S. Army 2002a, Appendix C).

3.10 SOCIOECONOMIC

As discussed previously, the DU Impact Area encompasses approximately 2,080 ac (6.42 km^2) and located entirely within Jefferson County; however, JPG spans three counties in Indiana (Jefferson, Jennings, and Ripley). Since JPG is located in a rural area, a 4-mi (6.4-km) radius was considered in the evaluation of demographic data per the procedures established by NRC's Office of Nuclear Material

Safety and Safeguards (NMSS) in U.S. Nuclear Regulatory Commission Regulation (NUREG) 1748, Appendix C (NRC 2003). Demographic data were obtained for the census block groups (U.S. Census Bureau 2013) within the 4-mi (6.4-km) radius, as well as for Jefferson County and the State of Indiana, and are presented in Table 3-11.

Table 3-11. Summary of 2010 Demographic Data Using Census Block Groups Jefferson Proving Ground, Madison, Indiana

Location	2010 Population	2000-2010 % Change	2020 Projected Population	% White	% Black	% Asian	% Other	Median Income
State of Indiana	6,483,802	6.63	6,481,489	84.3	9.1	1.6	2.7	$48,393
Jefferson County	32,428	2.28	35,340	95.2	1.7	0.7	0.9	$43,635
4-mile Radius of DU Impact Area	7,157	3.08	NA	98.28	0.98	0.35	0.39	$37,645

Sources: http://factfinder2.census.gov/bkmk/table/1.0/eNACS/11_5YR/DP03/0400000US18 and http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none.

The total population within the 4-mi (6.4-km) radius identified above is 7,157 people. The total population residing in a 4-mi (6.4-km) radius is estimated conservatively (i.e., tends to be overestimated) because these data are available at the census block group level that actually extend even farther than 4 mi (6.4 km) from the DU Impact Area and, thus, includes more people. The following census block groups were used to determine the demographic data for the 4-mi (6.4-km) radius surrounding the DU Impact Area:

- Jefferson County, Census Tract 9660, Block Group 1
- Jefferson County, Census Tract 9661, Block Groups 1 and 2
- Jennings County, Census Tract 9602, Block Group 3
- Ripley County, Census Tract 9687, Block Group 3.

In comparison, the population of Jefferson County and the State of Indiana is 32,428 and 6,483,802, respectively. A comparison of 2000 and 2010 census data for the 4-mi (6.4-km) radius, Jefferson County, and the State of Indiana indicates population increases of 3.08, 2.28, and 6.63 percent, respectively. The 2020 projected population increase for Jefferson County is estimated to be substantially higher than the actual population growth that occurred between 2000 and 2010 and is projected to be 8.9 percent. The majority of residents (98.28 percent) in the 4-mi (6.4-km) radius are white. This percentage is higher than the percentage of white residents for Jefferson County and the State of Indiana. The African American or black population within the 4-mi (6.4-km) radius of the DU Impact Area is 0.98 percent compared to 1.7 percent in Jefferson County. The median income for residents within the 4-mi (6.4-km) radius was $37,645 in 2010. The minority and low-income population are further evaluated in the environmental justice discussion in Section 4.11.

No employment data were available at the census block group level in this area; therefore, the Jefferson County data from the 2009 to 2011 American Community Survey (ACS) were used. Significant employment sectors for Jefferson County are educational services, health care, and social assistance (26 percent), manufacturing (25.8 percent), and retail trade (12.5 percent). The employment sectors are summarized further in Table 3-12.

Jefferson County's unemployment rate (population of 25,991 for ages 16 and over) was determined to be 8.1 percent from the 2007 to 2011 ACS. During the same ACS survey, the unemployment rate for the State of Indiana (population of 5,035,313 for ages 16 and over) was 9 percent (see http://factfinder2.census.gov/).

The nearest populated area is south of the firing line. People currently live and work in the JPG cantonment area on a daily basis. Presently, there are 13 residences south of the firing line. The civilians

Table 3-12. Summary of Employees by Industrial Sector in Jefferson County Jefferson Proving Ground, Madison, Indiana

Sector	Number of Employees
Agricultural, forestry, fishing, hunting, and mining	264 (1.9%)
Construction	617 (4.4%)
Manufacturing	3,656 (25.8%)
Wholesale trade	239 (1.7%)
Retail trade	1,775 (12.5%)
Transportation, warehousing, and utilities	728 (5.1%)
Information	128 (0.9%)
Finance, insurance, real estate, and rental and leasing	344 (2.4%)
Professional, scientific, management, administrative, and waste management services	628 (4.4%)
Educational services, health care, and social assistance	3,676 (2.6%)
Arts, entertainment, recreation, accommodation, and food services	1,046 (7.4%)
Other services except public administration	580 (4.1%)
Public administration	466 (3.3%)
Total civilians employed (16 years and older)	**14,147**

Source: U.S. Census Bureau, 2009-2011 ACS

employed work in light industry and a small number support the agricultural industry. There are no schools, churches, or cemeteries within the residential community. Rural churches and cemeteries are located around the perimeter of the installation. The closest town of significant size is Madison, Indiana, and is located approximately 6 mi (9.65 km) from the DU Impact Area. The 2010 population of Madison was determined to be 11,967 people.

Army personnel visit the area on a regular basis to verify that FWS and INANG are complying with the terms of the MOA (U.S. Army 2000a). Currently, FWS has multiple full-time personnel and several others that serve short-term internships at the installation.

3.11 PUBLIC AND OCCUPATIONAL HEALTH

Under the Proposed Action (i.e., restricted release with institutional controls to ensure continued future protectiveness of the site), the Army, in coordination with FWS and INANG, will maintain control of and restrict access to the DU Impact Area as well as to other areas, which contain UXO but do not contain DU. The use of institutional controls will ensure that those limited individuals who access specific portions of controlled areas are aware of the potential hazards and limit activities to those which are specifically authorized. Although the DU Impact Area contains both UXO and DU, the UXO presents the immediate and most serious hazard to potential intruders into the DU Impact Area. This section identifies potential exposure scenarios and estimates the potential human health impacts from implementation of these scenarios. Both normal, expected case scenarios and abnormal or accidental scenarios are identified and evaluated. Although both radiological and nonradiological hazards at JPG have been addressed, nonradiological toxicological hazards are limited to the cantonment area south of the firing line and are not, therefore, addressed in detail in this document. In addition, although analyses generally address both an implementation phase (i.e., the period over which actions to terminate the license are conducted) and a post-implementation phase (i.e., the period after the license has been terminated), given the status and nature of the Proposed Action, an implementation phase is not included. Rather, access to the area north of the firing line will continue to be controlled in accordance with the Record of Decision (ROD) (U.S. Army 1996a) and MOA (U.S. Army 2000a).

3.11.1 Post-Implementation Phase Impacts

Under the Proposed Action, institutional control of the site would be maintained and access to the DU Impact Area would be limited. This section identifies and analyzes scenarios that could result in impacts either to site workers or members of the public under expected conditions (i.e., institutional controls remain in place) and conditions that are plausible but not expected to occur (i.e., the failure of institutional controls). Radiological impacts of scenarios involving exposure to radioactive materials were analyzed using the Residual Radiation (RESRAD)-OFFSITE Version 2.6 (Yu et al. 2010). Although both radiological and nonradiological impacts would generally be evaluated for each scenario, significant sources of chemical (nonradiological) exposure were confined to the cantonment area of the installation and are not applicable to the DU Impact Area. Additional information on these sources and expected levels of exposure are contained in the RI (MWH 2002).

3.11.2 Major Sources and Levels of Background Radiation Exposure

Dose limits prescribed by Title 10 Code of Federal Regulations (CFR) Section 20, Subpart E are defined with respect to residual radioactivity distinguishable from background to the average member of the critical group. With respect to background, NRC notes that "On average, Americans receive a radiation dose of about 0.62 rem (620 millirem [mrem]) each year (6.2 millisievert [mSv]/yr). Half of this dose comes from natural background radiation. Most of this background exposure comes from radon in the air, with smaller amounts from cosmic rays and the Earth itself. The other half (0.31 rem or 310 mrem) (3.1 mSv) comes from man-made sources of radiation, including medical, commercial, and industrial sources. In general, a yearly dose of 620 millirem (6.2 mSv) from all radiation sources has not been shown to cause humans any harm" (see http://www.nrc.gov/about-nrc/radiatioNAround-us/doses-daily-lives.html).

With respect to site background radioactivity, studies were performed in 1995 and 2008 to quantify site background levels prior to conducting measurements in the DU Impact Area. Thirty-five background measurements were taken south of the firing line in a nonimpacted area for the 1995 study. An average background value of 12 microRoentgen per hour (μR/hr) was established for this area consistent with background levels determined in 1983. Background exposure rates ranged from 6 to 8 μR/hr on roads and in creek beds to a high of 10 to 12 μR/hr in open fields and wooded areas (SEG 1995).

In addition, a comprehensive background study was performed in the fall of 2008 to assess the presence of uranium in the predominant soil types present in the DU Impact Area. Soils investigated included Avonburg/Cobbsfork, Cincinnati/Rossmoyne, and Grayford/Ryker. Data collected addressed surface soils (i.e., uppermost 0.5 ft [0.15 m]) and subsurface soils at depths BGS of 0.5 to 1 ft (0.15 to 0.3 m), 1 to 2 ft (0.3 to 0.61 m), and 2 to 4 ft (0.61 to 1.22 m). Nine background surface soil samples were collected for each of the cited soil type groupings such that the surface soil data set included results from a total of 127 samples. These surface soil results reflected means of 1.5 ± 0.1 picocuries per gram (pCi/g) for Avonburg/Cobbsfork, 1.6 ± 0.2 pCi/g for Cincinnati/Rossmoyne, and 1.5 ± 0.2 pCi/g for Grayford/Riker. The overall mean across all soil types was 1.5 ± 0.2 pCi/g inclusive of all 127 background soil samples. These background data are reported with two significant digits and two standard deviation errors.

Comparison of surface soil and sediment results collected as an integral part of the ERM program between December 2004 and October 2012 (see Sections 6.1.2.4 and 6.1.2.5 for soil and sediment data, respectively) with site background surface soil data supports the conclusion that the uranium present at each of the four surface soil locations and at each of the nine sediment sampling locations is within the range of surface soil background. In addition, with respect to sediment, it is notable that the mean and associated standard deviation for each sediment sampling location are within the range of surface soil background and does not reflect a buildup of DU.

3.11.3 Current Sources and Levels of Exposure to Radioactive Material

Levels of exposure to radioactive material are the result of residual quantities (i.e., approximately 73,500 kilograms [kg]) of DU metal and associated oxidation and corrosion products, which are present in the DU Impact Area as a result of soft target lot acceptance testing of 105-millimeter (mm) and 120-mm DU kinetic energy penetrators by the Army. It is notable that each penetrator or portion thereof served as a point source rather than forming a homogeneous mixture of DU in site soils. As such, soil-borne uranium concentrations vary from background to essentially pure DU with an activity concentration of up to about 3.6×10^{-7} curies per gram (Ci/g) (1.3×10^{-2} Megabecquerels per gram [MBq/g]). Although Army DU typically exhibits a specific activity of about 3.42×10^{-7} Ci/g (1.2×10^{-2} MBq/g), a value of 3.6×10^{-7} Ci/g (1.3×10^{-2} MBq/g) is used if sample specific radioanalytical data are not available (10 CFR 20, Appendix B Footnote). The specific activity for DU translates to 0.0010, 0.200, and 99.7990 percent by mass of uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238), respectively.

DU in the DU Impact Area is concentrated along three lines of fire with about 89, 7, and 4 percent of the penetrators being fired from the 500 Center, J (i.e., westernmost), and K5 (i.e., easternmost) firing points, respectively. As a result, penetrator deposition was predominantly in and around impact trenches formed by the travel of the penetrators after impact with the soft targets. In addition, it is notable that the Army performed semi-annual visual inspections together with Geiger-Müeller (GM) detector surveys each spring and fall. These investigations also included controlled burns each fall to facilitate locating penetrators for investigations used to identify and remove DU penetrators located on the ground surface in the most highly impacted portions of the DU Impact Area (i.e., primarily in and around the trenches). The collection of penetrators significantly reduced the quantity of DU available to serve as the radioactive material source term.

A significant amount of both U-235 and U-234 are removed from natural uranium at the time of creating DU. As a result, the exposure level from DU is the result primarily of alpha decay of the U-238 parent and beta/gamma decay of thorium-234 (Th-234) and protactinium-234 (Pa-234) daughters. In addition, DU contains concentrations of U-235 and U-234 and, if the DU resulted from a reprocessing operation, the DU may contain trace contaminants including plutonium-239/240 (Pu-239/240) and technicium-99 (Tc-99) at concentrations of less than 3 and 400 pCi/g, respectively (U.S. Army 2002a).

Although the 63 and 93 kilo-electron volt (keV) gammas emitted by the Th-234 daughter provide a source of radiation with which to detect, identify, and quantify the amount of U-238 present, sodium-iodide (NaI) gamma scintillation detectors tend to over-respond to these energies by a factor of 4 to 5 relative to cesium-137, which is the radionuclide generally used for their calibration. When using field instruments to quantify exposure levels from U-238 by measuring Th-234 (i.e., daughter of U-238 and is present at the same activity as U-238 due to secular equilibrium), measurements using microrem detectors are commonly preferable to those made with microRoentgen (μR) detectors, which contain NaI scintillation detectors.

Previous scoping and characterization surveys (SEG 1995, 1996) performed in the mid-1990s used a correlation of 14.4 μR/hr as an indicator of soils in which the DU concentration exceeded 35 pCi/g, a common derived concentration guideline level (DCGL) during this time period. This survey estimated that about 125 ac (12.5 km^2) of land area in the DU Impact Area was affected by DU such that it exceeded 35 pCi/g.

Extensive gamma walkover surveys, soil sampling, and ancillary testing (e.g., corrosion study, leachability testing, site-specific K_d determination) was performed using samples collected in 2008 and 2012 to augment previously existing site data. Assessment of all data collected to date including operational surface danger zone (SDZ) fans resulted in designation of a primary contamination zone (PCZ) consisting of the area 82 ft (25 m) wide and 3,281 ft (1,000 m) long (i.e., 269,098 ft^2 [25,000 m^2] or 6.3 ac [0.03 km^2]) between C Road and Big Creek along the 500 Center Trench. The PCZ conservatively contains about 14,000 kg of DU. In addition, the secondary contamination zone (SCZ) was 2,625 ft (800 m) wide by 8,202 ft (2,500 m) long placed from C Road to 8,202 ft (2,500 m) north of C Road and including the area between the J and the K5 lines of fire as a conservative representation of the area containing the remaining DU from the DU penetrator distribution study (i.e., $2.15 \times ft^2$ [2×10^6

m^2] or 490 ac [1.98 km^2]) and contained the balance of the DU (i.e., about 60,000 kg) (see Figure 3-16 for locations of both the PCZ and SCZ).

3.11.4 Major Sources and Levels of Chemical Exposure

Major sources of chemical (nonradiological) exposure were confined to the cantonment area of the installation south of the DU Impact Area and are not, therefore, applicable to the DU Impact Area. Additional information on these sources and expected levels of exposure are contained in the RI (MWH 2002).

3.11.5 Historical Exposures to Radioactive Materials

Minimal access to the DU Impact Area has been authorized historically based on the presence of relatively large quantities of UXO (estimated to be 85 high-explosive UXO rounds per acre) present in the area. Activities involving access to the DU Impact Area generally were limited to activities such as:

- Semi-annual visual inspections to identify and collect DU penetrators primarily from limited areas, which had previously been subjected to surveys and clearance of UXO
- Maintenance of targets and associated test instrumentation
- Collection of ERM program samples
- Maintenance of security fencing, radiological warning signs, and gates.

Discussions with one former JPG Radiation Safety Officer (RSO) indicates that during the period in which the DU Impact Area was operational, measurable radiation exposures were limited to low levels of exposure encountered in conjunction with semi-annual activities to locate and collect DU penetrators (Personal Communication 2013c).

3.11.6 Occupational Injury Rates and Occupational Fatality Rates

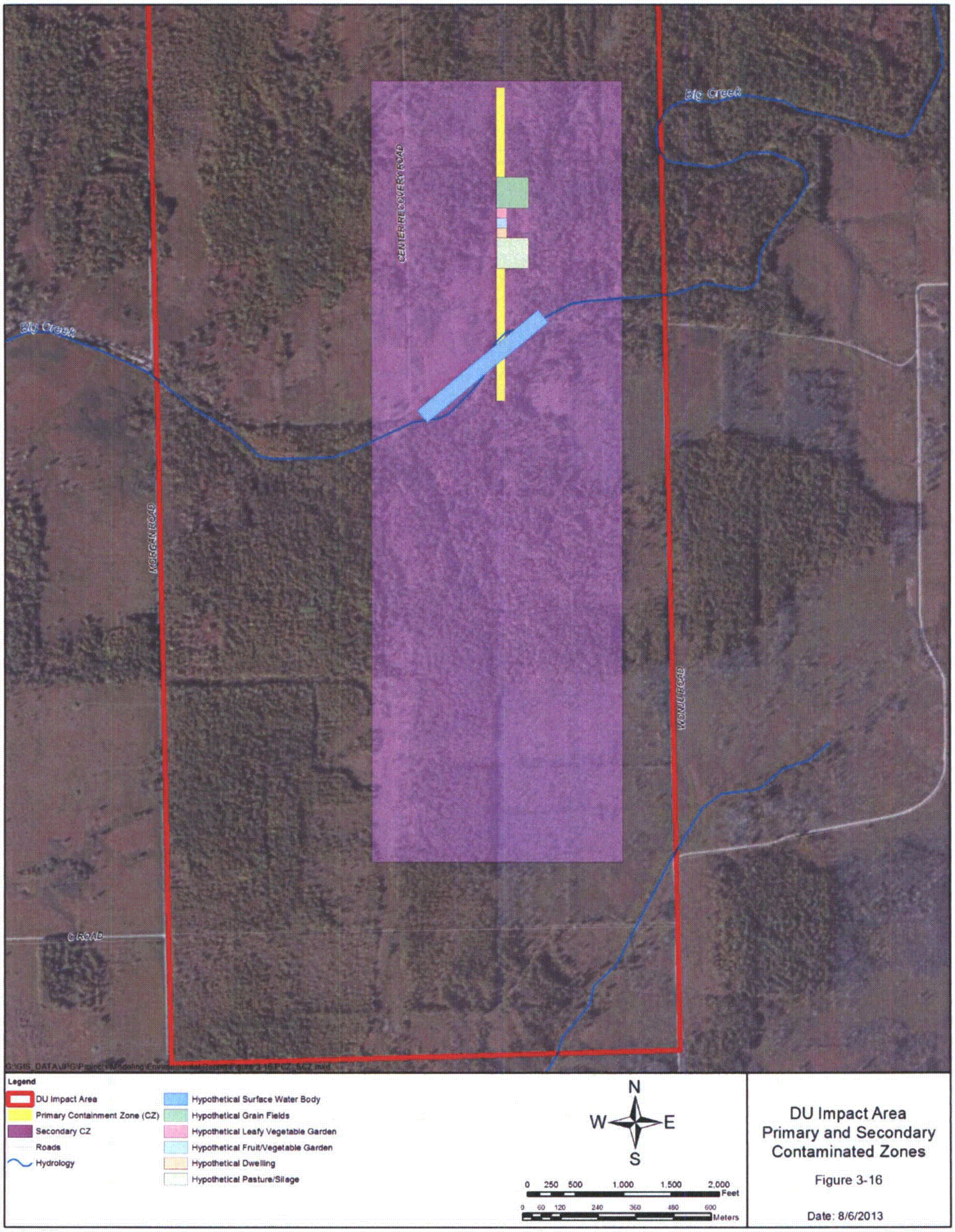
Given the care exercised when entry into the DU Impact Area and other areas with UXO is required, no fatal accidents have been identified. In addition, review of occupational injury rates for ammunition manufacturing employees reflects a current Occupational Safety and Health Administration (OSHA) injury rate of 1.3 incidents per year per 100 employees. Historical OSHA recordable occupational injury rates for 1995 equate to 6.8 recordable incidents per year per 100 employees (ammunition manufacturing Standard Industrial Code 3483).

3.11.7 Summary of Health Effects Studies

The following sections discuss the health effects associated with potential exposures to DU with institutional controls in place for average members of the critical group.

3.11.7.1 Assessment of Expected Conditions (Institutional Controls Function as Designed)

Institutional controls for JPG include continued Army ownership of all of the property north of the firing line, maintenance of the fence and perimeters signs that surround the area north of the firing line, access control to all north of the firing line JPG pad locked entrance gates, and use of a physical barrier (i.e., a fence) to separate the area north of the firing line from uncontrolled areas in the southern portion of the installation. The exterior fence from the firing line north is inspected on a weekly basis. In accordance with the MOA (U.S. Army 2000a), INANG performs these inspections. Public access to areas north of the firing line is strictly controlled.



DU Impact Area
Primary and Secondary
Contaminated Zones

Figure 3-16

Date: 8/6/2013

3.11.7.2 Sportsmen and Visitors

In accordance with the MOA (U.S. Army 2000a) and Public Access Plan (FWS 2012), FWS permits sportsmen and other members of the public to have limited access to those portions of the Big Oaks NWR that do not contain DU or large quantities of UXO. FWS has rules and regulations for assigning visitors to specific areas on the refuge with the DU Impact Area being closed to all public access. Visitors to Big Oaks NWR can participate in guided tours, wildlife observation and photography, fishing in Old Timbers Lake, and turkey or deer hunting. As each of these activities occurs outside the areas with DU contamination, no exposure to residual DU is anticipated. Only site workers and official visitors can enter the DU Impact Area with the durations/exposure times for such entries being very limited.

Although access to Big Oaks NWR for hunting is limited to the durations of hunting seasons (6 to 15 days) (FWS 2012), the residual radiation dose assessment is based on the assumption that a single individual is present in the NWR for 103 days per year and that hunting, fishing, and all other activities occur in the PCZ. Exposure pathways for these individuals include external radiation, inhalation, incidental soil and water intake, meat ingestion, and fish consumption. Given that hunters who consume game that has grazed within the DU Impact Area could receive some dose from residual DU contamination, this pathway was specifically assessed. To evaluate the total effective dose equivalent (TEDE) associated with consumption of deer meat, a total of 132 tissue samples from 30 deer were collected and analyzed during the winter of 2005/2006. DU was not detected in any tissue sample during laboratory analysis. As such, uptake of uranium as a result of the ingestion of deer meat is not a significant exposure pathway at JPG (the NRC testimony at the Administrative Hearing of 22 October 2007 indicated that if all the beef in a person's diet were replaced by deer meat with the highest reading obtained from these 30 samples for a year the increased exposure would be less than 1 mrem). Nonetheless, as a conservative approach, consumption of meat from a deer exposed to vegetation, soils, and water in the DU Impact Area was included as a complete pathway and the associated dose was included in exposure estimates.

If the DU used in the production of the kinetic energy penetrators originated at U.S. Department of Energy (DOE) facilities that processed recycled uranium, there is the potential for very low levels of transuranics and Tc-99 to be present in the DU. Based on information from DOE (DOE 2000a) and Pu measurements of samples where DU ammunition was fired in Kosovo (BBC 2001), it was concluded that Pu-239/Pu-240 could be present in the DU in concentrations of about 1 part per billion.

Given reprocessed DU containing trace contaminants Pu-239/240 and Tc-99 at concentrations of less than 3 and 400 pCi/g, respectively (U.S. Army 2002a), the dose to the resident farmer with loss of institutional controls would increase by less than 0.4 percent, a negligible increase. In terms of dose, a 0.4 percent increase equates to doses of less than 0.1 and 0.001 millirems per year (mrem/y) (1×10^{-3} and 1×10^{-5} milliSieverts per year [mSv/y]) for Tc-99 and Pu-239/240, respectively. As such, the potential dose associated with these radionuclides is insignificant and was, therefore, excluded.

Computation of the peak dose over the 1,000-year period of interest resulted in an estimated maximum TEDE of 3.3 mrem/y (0.033 mSv/y) for sportsmen and NWR visitors in the event of loss of institutional controls. The TEDE, although fully protective with or without institutional controls being in place, is much lower than this value with institutional controls in place. Since the TEDE for sportsmen and NWR visitors is so much lower than the 25 mrem/y (0.25 mSv/y) unrestricted release dose criterion contained in 10 CFR 20.1402, the calculation is not performed for the scenario with institutional controls in place.

3.11.7.3 FWS/INANG Site Workers

Institutional controls required for JPG by the ROD (U.S. Army 1996a) are addressed in the MOA (U.S. Army 2000a) between the Army, FWS, and USAF/INANG. Institutional controls necessitate that site personnel occasionally access the DU Impact Area for inspection or maintenance functions. These activities are expected to be of short duration and to exclude site remediation. Under this scenario, a site worker is assumed to spend 2,000 hours (i.e., a full work year) outdoors in the DU Impact Area in the PCZ. Pathways for this worker include external radiation, inhalation, and incidental soil ingestion. Drinking water is assumed to be obtained from a municipal drinking water source. The estimated peak annual dose for this site worker over the 1,000-year period of interest is 5.9 mrem/y (0.059 mSv/y) in the event of loss of institutional controls and is much lower with institutional controls in place.

The TEDE for sportsmen and visitors and FWS/INANG site workers is very low relative to the dose standard of 25 mrem/y (0.25 mSv/y) mandated in 10 CFR 20.1402 and 10 CFR 20.1403 for unrestricted and restricted release, respectively. It also is low compared to the dose of 310 mrem/y (3.1 mSv/y) cited by NRC as the annual natural background dose to an individual (see http://www.nrc.gov/about-nrc/radiatioNAround-us/doses-daily-lives.html).

3.11.8 Offsite Activities

Uranium could be transported offsite in surface water flowing through the DU Impact Area. Review of environmental monitoring data collected semi-annually from December 2004 through October 2012 indicates that the total uranium concentrations in surface waters (i.e., Big Creek, Middle Fork Creek, and northern tributary that converges with Big Creek) that flow through the DU Impact Area ranges from 0.04 to 19 picocuries per liter (pCi/L) with a mean concentration of 0.88 ± 2.4 pCi/L (error reported with 2 standard deviations). NRC has determined that a uranium concentration of 300 pCi/L corresponds to a dose of 50 mrem/y (0.5 mSv/y) if all drinking water is taken from a water source with that concentration (10 CFR 20, Appendix B). As such, based on these conservative assumptions, the highest and mean surface water concentrations (i.e., 19 and 0.88 pCi/L) would equate to doses of 3.2 and 0.15 mrem/y (0.032 and 0.0015 mSv/y), respectively.

Given the agricultural nature of the areas around JPG, the dose to a resident farmer located at the boundary to the installation (i.e., about 1.86 mi [3 km] west of the DU Impact Area) was modeled. Pathways included in this scenario included:

- External exposure to DU in soil deposited by flooding
- Inhalation of fugitive dust containing DU blowing in from JPG
- Ingestion of crops, meat, and milk from livestock raised on soils contaminated by fugitive dust deposition
- Ingestion of fish from stream or pond contaminated by DU leaching through soil and transporting from JPG
- Use of surface water downstream from JPG for irrigation of crops and consumption by livestock used for the production of milk and meat
- Incidental ingestion of DU-contaminated soil
- Use of drinking water that contains DU from JPG.

The TEDE to the resident farmer was determined to be 2 mrem/y (0.02 mSv/y).

3.11.9 *Assessment of Conditions Not Expected to Occur (Failure of Institutional Controls)*

Although institutional controls are used to restrict public access to areas north of the firing line that contain UXO and DU, a failure of these controls could occur. The hazard from a short-term failure of institutional controls, resulting in an individual spending time in the DU Impact Area, would be dominated by the UXO hazard, which could lead to injury or death. With regard to potential radiological hazards associated with DU, as noted previously in this section, the TEDE in the event of loss of institutional controls equates to 3.3 and 5.9 mrem/y (0.033 and 0.059 mSv/y) for sportsmen and visitors and FWS and INANG site workers, respectively, and is much lower than this estimate if institutional controls remain effective.

In the event of loss of institutional controls, it is also plausible that a resident farmer could construct a residence and implement subsistence farming on the DU Impact Area. As resident farmers would constitute the critical group, the TEDE for such a scenario was evaluated. This scenario was derived based on placement of a dwelling site (10,764 ft^2 [1,000 m^2]), leafy vegetable garden (10,764 ft^2 [1,000 m^2]), nonleafy vegetable and fruit garden (10,764 ft^2 [1,000 m^2]), livestock grain fields (107,639 ft^2 [10,000 m^2]), and livestock pasture/silage growing area (107,639 ft^2 [10,000 m^2]) directly on the DU Impact Area. Pathways for the residence farm included:

- External exposure to DU in soil
- Inhalation of fugitive dust containing DU
- Ingestion of crops, meat, and milk from livestock raised on DU-contaminated soil
- Ingestion of fish from stream or pond contaminated by DU leaching through soil
- Incidental ingestion of DU-contaminated soil
- Ingestion of drinking water that contains DU
- Ingestion of crops, meat, and milk that have been produced with the contaminated water.

As detailed in Appendix C of the Decommissioning Plan (U.S. Army 2013a), the critical group under circumstances such that institutional controls are no longer in effect is the onsite resident farmer with assumed irrigation (i.e., insufficient water is available for farming at the DU Impact Area, so RESRAD modeling conservatively assumes that irrigation and drinking water are obtained by damming of Big Creek). The TEDE to the resident farmer was determined to be 26.3 mrem/y (0.263 mSv/y). This dose is essentially indistinguishable from the 25 mrem/y (0.25 mSv/y) dose standard prescribed in 10 CFR 20.1402 for unrestricted release. In addition, pursuant to 10 CFR 20.1403, license termination under restricted conditions limits, the TEDE, distinguishable from background to the average member of the critical group allows up to 25 mrem/y (0.25 mSv/y). In addition, the residual radioactivity at the site also must be reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable (ALARA) and would not exceed 100 mrem/y (1 mSv/y) (or 500 mrem [5 mSv] with additional requirements). Given that the peak annual dose over the 1,000-year period of interest for sportsmen and visitors and FWS and INANG site workers (i.e., the critical groups with institutional controls in place) equate to a maximum of only 3.3 mrem/y (0.033 mSv/y) and 5.9 mrem/y (0.59 mSv/y) in the event of loss of institutional controls and are much lower than these values with institutional controls in place, the JPG DU Impact Area clearly complies with 25 mrem/y (25 mSv/y) dose standard mandated by 10 CFR 20.1403. In addition, the dose to the resident farmer, the critical group in the event of loss of institutional controls, equates to 26.3 mrem/y (0.263 mSv/y), is far below the dose standard of 100 mrem/y (1 mSv/y) prescribed in 10 CFR 20.1403 in the event of loss of institutional controls and is essentially indistinguishable from the unrestricted release dose limit of 25 mrem/y (25 mSv/y).

Uranium and thorium sites are generally subjected to durable and legally enforceable institutional controls with 5-year reviews (NRC 2006a): "It may be appropriate to treat sites with longer half-life radionuclide contamination, but with doses close to 25 mrem/y (0.25 mSv/y) assuming no controls as 'Low Risk' sites." As such and given that the TEDE to the resident farmer (i.e., the average member of the critical group in the event of loss of institutional controls) in the DU Impact Area is essentially indistinguishable from the 25 mrem/y (0.25 mSv/y) unrestricted release dose standard, the Army proposes to manage the site as a low risk site without regard to 5-year reviews.

3.12 WASTE MANAGEMENT

Given that remediation of the DU Impact Area is not planned for license termination under restricted release criteria, radioactive waste will not be generated or managed except in rare and unexpected situations described below. This is particularly true given that access to the DU Impact Area will be severely limited and that potentially DU-contaminated UXO items encountered in the DU Impact Area would commonly be "blown in place" rather than to be decontaminated and moved to another area to be detonated/rendered safe.

4. ENVIRONMENTAL IMPACTS

The known and potential environmental impacts (e.g., direct, indirect, and cumulative) from implementing Alternative 1, license continuation (No Action), and Alternative 2, license termination under restricted conditions with institutional controls to ensure continued future protectiveness of the site (Proposed Action), are described in this section. Sections 4.1 through 4.13 address the following potential impacts associated with the implementation of each alternative: land use, transportation, geology and soils, water resources, ecological resources, air quality, noise, historic and cultural resources, visual/scenic resources, socioeconomics, environmental justice, public and occupational health, and waste management.

4.1 LAND USE IMPACTS

There would be no land use impacts (direct or indirect) from the No Action alternative or the Proposed Action other than those that exist under the baseline conditions described in Section 3.1. The Depleted Uranium (DU) Impact Area would continue to be restricted from public access. The land in the area north of the firing line would continue to be managed in accordance with the Memorandum of Agreement (MOA) (U.S. Army 2000a).

Implementation of the Proposed Action would not result in any changes to current land use. Access to the DU Impact Area would continue to be controlled in accordance with the Jefferson Proving Ground (JPG) "Disposal and Reuse Environmental Statement Record of Decision" (ROD) (U.S. Army 1996), which states that "The Army will maintain and secure the property while in caretaker status," which is consistent with the MOA negotiated between the Army, U.S. Air Force (USAF), and U.S. Fish and Wildlife Service (FWS) (U.S. Army 2000a). The Army would continue to consult with both FWS and the Indiana Air National Guard (INANG), as USAF users of portions of the JPG property north of the firing line under an Army approved sub-lease, to ensure that ongoing activities are compatible with refuge and bombing range activities. No demolition, excavation, digging, drilling, or other disturbance of the soil, ground, or groundwater, or use of soil, ground, or groundwater for any purpose, will be permitted without written approval of the Army. The Army will retain authority, responsibility, and liability for potential remediation resulting from past Army activities at JPG as required by applicable laws in accordance with the signed ROD (U.S. Army 1996).

4.2 TRANSPORTATION IMPACTS

There would be no transportation-related impacts (i.e., contaminant releases or impacts on transportation routes and traffic patterns) under the No Action alternative or Proposed Action because no physical changes are planned under either alternative.

4.3 GEOLOGY AND SOILS IMPACTS

Existing natural vegetation would be preserved and no modifications to topographic contours would be made under the No Action alternative and Proposed Action; therefore, no impacts to geology and soils are expected to occur as a direct result of implementation of the No Action alternative or Proposed Action. In addition, it may be noted that vegetation acts to retard the transport of uranium, but after exposing soil by burning vegetation "risks associated with potential transport of DU in the air from controlled burns are negligible" (NRC 2008); thus, potential soil impacts from controlled burns are not significant.

Soil contamination levels and depths of contamination in the DU Impact Area are likely to remain essentially the same in the short-term, but additional migration of uranium with depth in the soil over the long-term is likely. Corrosion products from DU that had been distributed on or immediately below the ground surface in the DU Impact Area as a result of penetrator proof testing may be transported through the soil column from shallow into deeper soils. While some processes may cause migration and transport of DU corrosion products along the ground surface to surface water drainageways or transport through fugitive dust dispersion through the atmosphere, leached DU corrosion products from the penetrators and/or fragments into the surface soil potentially could be transported through the soil column to groundwater and be ingested by humans, livestock (through irrigation), or wildlife (through groundwater seeps into streams). However, the annual water budget for the DU Impact Area indicates that the majority of the average annual 47 inches (in) of precipitation to JPG is lost either through evapotranspiration (26 in or 56 percent) or runoff (17 in or 36 percent) to local streams. This leaves only approximately 4 in (8 percent) available to infiltrate into soil and potentially to groundwater in the overburden and shallow bedrock.

Some transport of DU has been observed. Seventy-three soil samples were collected in 1996 (SEG 1996) under penetrators from depths of 0 to 0.5, 0.5 to 1, 1 to 1.5, and 1.5 to 2 feet (ft) below ground surface (BGS). Total uranium concentrations in these samples ranged from 1.4 ± 0.2 to 12,000 ± 180 picocuries per gram (pCi/g). The average total uranium activity for samples collected from 0 to 2.0 ft BGS was 820 ± 16 pCi/g. As described in greater detail in Section 6, 96 soil samples were collected in October 2008 from under penetrators from depths of 0 to 0.5, 0.5 to 1, 1 to 2, 2 to 4, and 4 to 6 ft BGS. Total uranium concentrations ranged from 15 ± 13 to 29,000 ± 140 pCi/g. The average total uranium activity for samples collected from 0 to 4 ft BGS is 5,000 ± 50 pCi/g.

The DU corrosion rate in soil is also variable and is known to depend on soil characteristics (e.g., type, pH, water content) and burial depth among other factors. Eventually, the penetrators will fully corrode and return to their natural state. Based on laboratory studies conducted using penetrators recovered from the DU Impact Area and literature searches, the characteristics and quantities of the penetrators fired at JPG were used to determine the rate at which DU corrodes and the rate at which the resulting corrosion products enter the soil. The calculated times to complete corrosion and dissolution of the penetrator are as follows: most likely estimate is 107 years; 5th percentile is 182 years (slowest corrosion and dissolution); and 95th percentile is 65 years (fastest corrosion and dissolution) (i.e., the time required for penetrator corrosion and dissolution is projected to range from less than 66 years to more than 238 years with 103 years being the most likely duration). Residual Radiation (RESRAD) requires complete corrosion and dissolution in order for the model to function correctly. This is a conservative requirement of the model based on the most likely duration for complete penetrator corrosion and dissolution.

4.4 WATER RESOURCES IMPACTS

Under the No Action alternative and Proposed Action, the DU Impact Area will remain as it currently exists. The known and potential impacts are described below.

Residual DU could be transported to surface water. Surface water is currently monitored at the DU Impact Area under the Environmental Radiation Monitoring (ERM) program to ensure DU remaining within the DU Impact Area does not pose a risk to human health or the environment (U.S. Army 2013c). The ERM program provides a historical and current perspective of DU levels and a timely indication of the magnitude and extent of any DU release or migration from past operations. Results indicate low levels of total uranium activity at JPG are not indicative of significant trends or migration. Historical assessment from 145 discrete surface water samples collected from December 2004 through October 2012 (U.S. Army 2013d) showed an average total uranium concentration of 0.88 picocuries per liter (pCi/L), the standard deviation is 2.4 pCi/L, and the maximum detected concentration is 19 ± 2 pCi/L (U.S. Army 2013a). In addition to routine periodic ERM monitoring, site investigation data have been collected to further define the nature and extent of DU in the environmental media within and adjacent to the DU Impact Area. Surface water samples were collected quarterly in April 2008, July 2008, October 2008, and February 2009. Ninety total surface water samples were collected from 13 background and 77 site locations. Background concentrations of total uranium ranged from 0.047 to 2.83 pCi/L with a mean of 0.44 pCi/L. Total uranium results in Big Creek and Middle Fork Creek ranged from 0.036 to 20.3

pCi/L with a mean of 1.3 pCi/L. The highest observed concentrations were observed where runoff is expected to enter Big Creek from the DU impact trench. Semi-annual environmental monitoring with isotopic analysis by alpha spectrometry was initiated in December 2004. Review of uranium-238:uranium-234 (U-238:U-234) isotopic activity ratios from December 2004 through October 2012 indicate that 10 of 145 surface water samples and 1 of 202 groundwater samples exhibited activity ratios exceeding 3. None of the 151 sediment or 91 surface soil samples during this interval exhibited U-238/U-234 ratios exceeding 3. This supports the potential finding that most of the variation in uranium concentrations observed in surface water samples has been natural in origin, but it also indicates the potential presence of DU in surface water. This potential DU has mixed with naturally occurring uranium that has eroded from geologic deposits and could be transported by surface water flowing across the DU Impact Area and draining into Big Creek or Middle Fork Creek. Additional information about the fate and transport of DU in surface water (and sediment) in Big Creek and Middle Fork Creek is presented in Appendix E and residual radiation doses associated with drinking water are presented in Appendix C of the Decommissioning Plan (U.S. Army 2013a).

In addition to surface water monitoring, the ERM program also includes the routine, periodic monitoring of groundwater at the DU Impact Area (U.S. Army 2013c). Results indicate low levels of total uranium activity at JPG are not indicative of significant trends or migration in groundwater. Historical assessment from 202 discrete samples collected from 2004 through October 2012 showed the average total uranium concentration is 1.4 pCi/L, the standard deviation is 1.2 pCi/L, and the maximum detected concentration is 5.7 ± 0.6 pCi/L. In addition to the routine periodic ERM monitoring, site investigation data have been collected to further define the nature and extent of DU in the environmental media within and adjacent to the DU Impact Area. Groundwater samples were collected quarterly in April 2008, July 2008, October 2008, and February 2009. The quarterly monitoring included the collection and analysis of 189 total samples, including 44 samples from background wells and 145 samples from site wells. Some wells were periodically dry and could not be sampled. The wells were screened in different hydrostragraphic units: 14 overburden wells, 20 shallow bedrock wells, and 8 deep bedrock wells. Total uranium concentrations in samples collected from background wells ranged from 0.001 to 6.42 pCi/L with a mean of 1.2 pCi/L. Total uranium concentrations in samples collected from site wells ranged from 0.001 to 40.2 pCi/L with a mean of 2.5 pCi/L. The highest observed concentrations were observed southwest of the DU Impact Area in an overburden well (MW-RS-7). The data indicate no groundwater contamination attributable to the DU Impact Area. The ratio of U-238:U-234 in groundwater samples has been near 1, indicating the presence of naturally occurring uranium (U.S. Army 2013a). Additional information about the fate and transport of DU in soil and the potential for DU to impact groundwater is presented in Appendix B.

4.5 ECOLOGICAL RESOURCES IMPACTS

Impacts to ecological resources under the No Action alternative and Proposed Action would be identical to baseline conditions. Little to no impacts to wildlife are anticipated under the No Action alternative and Proposed Action.

Staff from the FWS Bloomington Ecological Services Field Office were contacted to determine if the Army would be required to conduct an informal consultation with FWS under Section 7 of the Endangered Species Act (ESA) for the termination of the Army's Materials License due to the presence of the Indiana bat at JPG in relation to the Proposed Action (Personal Communication 2013a). Because the Proposed Action (restricted release license termination) does not include any physical changes to the DU Impact Area and continuing use of the same institutional controls that restrict access north of the firing line and have been followed since the MOA was executed, FWS indicated that an informal consultation is not required. No habitat disturbances from the Proposed Action are expected. As a result, there is a no effect determination by the Army from the Proposed Action on the Indiana bat.

The Proposed Action would not result in direct impacts because no earthmoving activities would occur; however, residual DU would remain in the DU Impact Area. DU could leach into soil and groundwater, be taken up by plants, and, ultimately, consumed by animals. However, results of the biotic sampling discussed in Section 3.5 do not reflect the presence of uranium concentrations in tissue samples at levels exceeding background except for a small number of historical vegetation samples from areas near penetrator locations (SEG 1996). Despite elevated uranium concentrations in limited vegetation samples, there is no evidence of bioaccumulation of DU in the food chain based on animal tissue samples (SAIC 2006a).

4.6 AIR QUALITY IMPACTS

No air quality impacts would result from implementing the No Action alternative and Proposed Action. Activities that could degrade air quality would be limited to occasional vehicle movement near the DU Impact Area for fence and sign checking and maintenance.

Although there have been potential concerns about DU transport in the smoke that occurs during periodic controlled burning conducted at JPG by FWS personnel, air sampling and technical assessment of associated risks reflects that "risks associated with potential transport of DU in the air from controlled burns are negligible" (NRC 2008) with minimal increases in human doses (Williams et al. 1998; Johansen et al. 2001; Kraig et al. 2001a,b). In addition, the uncertainty introduced from modifications of the RESRAD-OFFSITE modeling program needed to assess this potential pathway do not justify including this pathway in the dose assessment. Thus, any dose from DU transported by smoke during fires was not specifically evaluated in the dose assessment. However DU transport through the inhaled dust pathway was considered and should adequately address smoke from controlled burns of DU-contaminated areas as a source. Additional information about the dose analysis is included in the Decommissioning Plan, Section 4 (U.S. Army 2013a) and Appendix C. Short-term, minor impacts to the air quality and visibility would occur as a result of FWS prescribed burns, which last less than 24 hours and are tended by FWS personnel until extinguished; however, these impacts are independent of the No Action alternative and the Proposed Action; thus, they would remain the same as described in Section 3.6.

4.7 NOISE IMPACTS

There would be no noise impacts from the No Action alternative or Proposed Action.

No earth-moving or vehicular traffic activities that could generate noise in the DU Impact Area would occur under either alternative; therefore, noise levels would remain at the baseline levels described in Section 3.7. However, minimal noise will be generated by "Routine Activities Authorized in the DU Impact Area" (e.g., maintenance of roads and control of vegetation by mowing and use of weed trimmers) (U.S. Army 2013b).

4.8 HISTORIC AND CULTURAL RESOURCES IMPACTS

The historic and cultural resources are described in Section 3.8. There would be no impacts to cultural resources from implementing the No Action alternative or Proposed Action.

No earth-moving activities are proposed. The land in the DU Impact Area has been disturbed previously to depths of 3 to 25 ft (0.9 to 7.6 meters [m]) BGS by the munitions testing activities over the course of JPG's operational history (Geo-Marine 1996). Neither continuation nor termination of the U.S. Nuclear Regulatory Commission (NRC) license under restricted release will result in further disturbance of the land in the DU Impact Area, or any of the historic or cultural resources located on JPG property north of the firing, none of which is located within the DU Impact Area.

4.9 VISUAL/SCENIC RESOURCES IMPACTS

The visual and scenic resources are described in Section 3.9. There would be no impacts on visual or scenic resources within the DU Impact Area under the No Action alternative or Proposed Action.

There would be no construction or cleanup activities associated with license termination under restricted release conditions. Short-term impacts to the visual landscape would continue as a result of FWS prescribed burns, as described previously in Sections 4.3 and 4.6; however, these impacts are independent of the Proposed Action.

4.10 SOCIOECONOMIC IMPACTS

There would be no socioeconomic impacts associated with the No Action alternative or Proposed Action. Army personnel will visit the site as required to fulfill the responsibilities outlined in the Radiation Safety Plan for the DU Impact Area (U.S. Army 2013b), including coordination with FWS and INANG pursuant to their agreed upon responsibilities. Currently, FWS has multiple full-time personnel and several others periodically serve short-term internships at the installation.

South of the firing line, people currently live and/or work in the JPG cantonment area on a daily basis. There are fewer than 20 residences currently located in the cantonment area south of the firing line. Working individuals are employed in light industry and a small number of individuals support farming.

4.11 ENVIRONMENTAL JUSTICE

There would be no environmental justice impacts from the No Action alternative or Proposed Action to terminate the license under restricted release.

To determine if there would be an environmental justice impact from the Army terminating its NRC license for the DU Impact Area, the procedures established by NRC's Office of Nuclear Material Safety and Safeguards in U.S. Nuclear Regulatory Commission Regulation (NUREG)-1748 (Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards [NMSS] Programs), Appendix C (Environmental Justice Procedures) (NRC 2003) were implemented. Demographic data were obtained using the 2010 U.S. Census information from the U.S. Census Bureau's American FactFinder website for the immediate site area, surrounding communities, the State of Indiana, and the surrounding counties and towns. JPG is located in a rural area; therefore, a 4-mile (mi) (6.4-kilometer [km]) radius was selected for analysis (NRC 2003). The distance from the DU Impact Area to the western and eastern boundaries of the installation is approximately 2 mi (3.2 km). The distance from the southern boundary of the DU Impact Area to the southern limit of the former installation is about 4.2 mi (6.2 km). This area includes the cantonment area where the land either has been or is being transferred for private and public use. The distance from the DU Impact Area to the northern boundary of the former installation is approximately 10 mi (16 km).

The total population residing in a 4-mi (6.4-km) radius is estimated conservatively (i.e., tends to be overestimated) because these data are available at the census block group level that actually extend even farther than 4 mi (6.4 km) from the DU Impact Area and thus includes more people. Section 3.10 summarizes population data at the city, county, and state levels. After determining the number of people who resided in the 4-mi (6.4-km) radius, the percentage of minority and economically stressed households (defined as the number of people below the U.S. poverty level of $22,113 for a family of four [U.S. Census Bureau 2013]) within that population was determined and compared to the total population of such groups at the state and county levels.

The minority population (i.e., black, asian, and other), within the 4-mi (6.4-km) radius was determined to be 1.7 percent using the 2010 U.S. Census information for the representative census block group levels. The minority populations of Jefferson County and the State of Indiana are about 3.3 and

13 percent, respectively. The percentage of minority population in the affected 4-mi (6.4-km) radius is below 10 percent and is lower than the county and state levels (U.S. Census Bureau 2013).

The potential for disproportionately high and adverse impacts to low-income populations then was evaluated using county data published through 2000 U.S. Census information because more recent data are not available and no data are available for low-income populations at the census block group level in this area. Following the guidance in Appendix C of NUREG-1748 (NRC 2003), the percentage of the affected population that was low-income was determined. This value was compared to the percentage of low-income populations at the state level. The percentage of low-income population in the State of Indiana is about 14 percent (U.S. Census Bureau 2013). Although the DU Impact Area is set entirely within Jefferson County, JPG spans three counties in Indiana (Jefferson, Jennings, and Ripley). The percentage of low-income populations residing in each of the three counties was averaged to obtain a value of about 12 percent (U.S. Census Bureau 2013). Section 3.10 indicates that the percentage of low-income populations within the 4-mi (6.4-km) radius was determined to be about 7.7 percent (U.S. Census 2013). The percentage of low-income population with the 4-mi (6.4-km) radius is below 10 percent and is lower than the county and state levels.

Because the minority and low-income populations residing in the area are significantly less than 20 percent of the affected population, environmental justice was not evaluated further as discussed in Appendix C of NUREG 1748 (NRC 2003).

4.12 PUBLIC AND OCCUPATIONAL HEALTH IMPACTS

This section discusses potential nonradiological and radiological impacts on public and occupational health in Sections 4.12.1 and 4.12.2, respectively. Under the No Action alternative and Proposed Action (i.e., restricted release with institutional controls to ensure continued future protectiveness of the site), the Army, in coordination with FWS and INANG, would maintain control of and restrict access to the DU Impact Area as well as to other areas that contain unexploded ordnance (UXO) but do not contain DU.

4.12.1 Nonradiological Impacts

As discussed in Section 3.12, the nonradiological hazards that could pose threats to public and occupational health at JPG include UXO. Although the DU Impact Area contains both UXO and DU, the UXO presents the immediate and most serious hazard to potential intruders into the DU Impact Area. UXO is present in high concentrations and poses a significant health and safety hazard to workers performing decommissioning activities on the 2,080-acre (ac) (8.4-square kilometer [km^2]) DU Impact Area site. Within the area designated as the DU Impact Area, the estimated UXO distribution is characterized as "very high" with an estimated 85 high-explosive UXO rounds per acre (U.S. Army 1995a). The presence of UXO constitutes a hazard to numerous kinds of activities that might occur in the area such as construction, intrusive activities, cross-country vehicular travel, and most agricultural and silvicultural operations. Unrestricted release of the site would potentially expose the public to the UXO hazard should the UXO not be addressed in the decommissioning and remediation activities. The estimated unit costs for surface and subsurface clearance of UXO were developed by modeling multiple scenarios using Remedial Action Cost Engineering and Requirements (RACER™) version 11.1 (AECOM 2012) cost estimation software and are approximately \$150,660/ac (\$37.23/m^2) for UXO surface and subsurface clearance of 5 ac (0.02 km^2) to a depth of 4 ft (1.2 m). The unit costs are approximately \$27,210/ac (\$6.72/m^2) for a UXO surface and subsurface clearance of 500 ac (2.0 km^2) to a depth of 4 ft (1.2 m). The scenarios assumed only UXO clearance activities and do not include DU remediation or additional care that may be required to conduct UXO clearance work in areas contaminated with DU (e.g., additional engineering controls to minimize spread of contamination during in-place destruction of UXO, decontamination of safe-to-move UXO before movement to other parts of project site where destruction and disposal can safely take place, potential remote/robotic operations needed due to safety concerns for dense quantities of UXO). The removal of the vegetation following the surface clearance also was not included.

JPG's operations throughout the base's history involved the use of a wide variety of hazardous materials and petroleum products. Several studies were performed to support environmental restoration program initiatives south of the firing line and standard environmental investigation techniques under the processes identified within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) were utilized to identify where those materials were used, stored, or released. Several remediation and long-term monitoring projects were completed or are underway to address these releases. Nonradiological hazards other than UXO are limited to the cantonment area south of the firing line. Consequently, they do not pose threats to public and occupational health at the DU Impact Area so, for this reason, they are not addressed further in this document. Additional information on these sources and expected levels of exposure are contained in the Remedial Investigation (RI) (MWH 2002).

4.12.2 Radiological Impacts

Under the No Action alternative and Proposed Action, institutional control of the site would be maintained and access to the DU Impact Area would be limited. This section identifies and analyzes scenarios that could result in impacts either to site workers or members of the public under expected conditions (i.e., institutional controls remain in place) and conditions that are plausible but not expected to occur (i.e., the failure of institutional controls). Radiological impacts of scenarios involving exposure to radioactive materials were analyzed using RESRAD-OFFSITE Version 2.6 (Yu et al. 2010) based on the protections defined in the RSP (U.S. Army 2013b) and in the event these protections are not followed.

Levels of exposure to radioactive material are the result of residual quantities (i.e., approximately 162,000 lbs [73,500 kilograms (kg)]) of DU metal and associated oxidation and corrosion products that are present in the DU Impact Area as a result of soft target lot acceptance testing of 105-millimeter (mm) and 120-mm DU kinetic energy penetrators by the Army.

4.12.2.1 Pathway Assessment

As defined in Title 10 Code of Federal Regulations (CFR) Part 20, Section 1003 (10 CFR 20.1003), "Critical Group means the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances." The average member of that group is a person expected to receive the dose from an ordinary use of the site based on the exposure scenario. Since each scenario developed is different and the critical group for a particular scenario varies accordingly, a more specific average member of the critical group is given in the scenario descriptions. For example, the average member of the critical group might be an individual worker who spends half of his or her work-days onsite and the other half inside a building, or the average member of the critical group might be the farmer who is involved in the daily operations of a working subsistence farm located within the contaminated zone. A potential critical group, then, is defined for each scenario, and the average member, to which the dose estimates apply, is specified. When calculating total effective dose equivalent (TEDE) to the average member of the critical group, the licensee determined the peak annual TEDE expected within the first 1,000 years after decommissioning (10 CFR 20.1402(d)). Based upon dose assessment results, the critical group when institutional controls remain in place is the FWS/INANG industrial worker working on JPG. The critical group if institutional controls are no longer in effect is the onsite (within the DU Impact Area) subsistence farmer.

The risk of adverse effects to and potential residual radiation doses for humans from inhalation, ingestion, or external radiation from residual DU depends on credible exposure scenarios from the DU source through the environment to human receptors. Several potential exposure scenarios were considered, and from these a subset was developed to simulate the most reasonable exposures of humans using radiologically impacted areas on JPG. Two sets of scenarios are developed: 1) those applicable with institutional controls in place, and 2) those which apply if the institutional controls are no longer in effect. Provisions for institutional controls proposed by the licensee must provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 millirems (mrem) (0.25 milliSieverts [mSv]) TEDE per year and must comply with other applicable provisions of 10 CFR 20.1403. In addition, the licensee must ensure that residual radioactivity at the site has been reduced so that if institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is ALARA and would not exceed either 100 mrem (1 mSv) per year (or 500 mrem per year subject to the provisions of 10 CFR 20.1403(e)(2)). In addition to the cited dose provisions, the licensee must demonstrate that further reductions in residual radioactivity necessary to comply with unrestricted release provisions of 10 CFR 20.1402 would result in net public or environmental harm or were not being made because the residual levels associated with restricted conditions are ALARA. Appendix C of the Decommissioning Plan (U.S. Army 2013a), Tables 5 and 6 list exposure scenarios with institutional controls in place and if institutional controls are no longer in place, respectively. Each of these scenarios was appropriately evaluated using RESRAD-OFFSITE Version 2.6 (Yu et al. 2010), which is a computer code that evaluates the radiological dose and excess cancer risk to an individual who is exposed while residing and/or working in or near an area where the soil is contaminated by radionuclides.

The main characteristics of the exposure scenarios when institutional controls are in place are that exposures are limited because site use and site access are limited. Based on the nature and duration of potential exposures, it was determined that FWS/INANG employees supporting Big Oaks National Wildlife Refuge (NWR) and Jefferson Range as well as members of the public entering JPG for recreational purposes (e.g., hunting and bird watching) were two potential critical groups. Given limited access beyond the site boundary (i.e., the fence that encloses the area north of the firing line, which remains under Army control), exposure scenarios were developed and evaluated.

4.12.2.2 Public and Occupational Exposure

Institutional controls for JPG include maintenance of the fence and perimeter warning signs that surround the border of the installation north of the firing line and access control to JPG north of the firing through a locked main access gate (gate #1A) located at the southeast corner of the of the firing line). A physical barrier (i.e., fence) separates the area north of the former firing line from uncontrolled areas in the southern portion of the installation. The exterior fence and signage are and will continue to be inspected on a routine basis. In accordance with the MOA (U.S. Army 2000a), USAF would perform these activities, which actually are performed by INANG as the USAF sub-leasee actually using a portion of the property north of the firing line. Public access to areas north of the firing line is and will continue to be strictly controlled. This section includes a discussion of:

- Potential public and occupational radiological exposures for sportsmen and visitors, FWS/INANG site workers, and offsite activities.
- Potential exposures and residual radiation doses should institutional controls fail. In the event of loss of institutional controls, resident farmers (onsite within the DU Impact Area) would constitute the critical group.

4.12.2.2.1 Sportsmen and Visitors

In accordance with the Public Access Plan (FWS 2012), FWS permits sportsmen and other members of the public utilizing an access control and accountability process, which has received prior Army review and approval, to have limited access to those portions of the Big Oaks NWR that do not contain DU. Only site workers and official visitors are authorized to enter the DU Impact Area with the durations/exposure times for such entries being very limited.

FWS developed a Public Access Plan (FWS 2012) with rules and regulations for Big Oaks NWR visitors. Visitors to the Big Oaks NWR can participate in guided tours; wildlife observation and photography; edible mushroom and berry collection; fishing in Old Timbers Lake; and squirrel, turkey, or deer hunting (only during specific times of the year). As each of these activities occurs outside of the areas with DU contamination, lack of complete exposure pathways precludes receipt of a measurable dose from DU.

Public access is limited to specific days of the week (i.e., Mondays, Fridays, and the second and fourth Saturdays of the month [closed on Federal holidays] during the public use period from mid-April through November) (see http://www.fws.gov/refuge/big_oaks). It is also accessed during seasonal periods such as deer, squirrel, and turkey hunting seasons. The Army and FWS will periodically re-evaluate public access to determine if different limits are more appropriate. Although access to the Big Oaks NWR for hunting is limited to one-time capacities (i.e., up to 500 people allowed for deer and fall turkey hunting) and to the durations of hunting seasons (e.g., up to 10 days per month from mid-August through November for squirrel hunting), the dose assessment is based on the assumption that a single individual is present in the NWR for 103 days per year and that hunting and all other allowable activities occur in the primary contaminated zone. Exposure pathways for these individuals include external radiation, inhalation, incidental soil and water intake, and meat ingestion. Given that hunters who consume game that has grazed within the DU Impact Area could receive some dose from residual DU contamination, this pathway was specifically assessed. To evaluate the TEDE associated with consumption of deer meat, a total of 132 tissue samples from 30 deer were collected and analyzed during the winter of 2005/2006 (SAIC 2006a). Laboratory analysis did not detect DU in any tissue sample. As such, uptake of uranium as a result of the ingestion of deer meat is not a significant exposure pathway at JPG. Nonetheless, as a conservative approach, consumption of meat from a deer exposed to the DU Impact Area was included as a complete pathway and the associated dose included in exposure estimates.

If the DU used in the production of the kinetic energy penetrators originated at U.S. Department of Energy (DOE) facilities that processed recycled uranium, there is the potential for very low levels of transuranics and technetium-99 (Tc-99) to be present in the DU. Based on information from DOE (DOE 2000b) and plutonium (Pu) measurements in samples of DU ammunition fired in Kosovo (BBC 2001), plutonium-239/240 (Pu-239/240) could be present in the DU in concentrations of about 1 part per billion.

Given reprocessed DU containing trace contaminants Pu-239/240 and Tc-99 at concentrations of less than 3 and 400 pCi/g, respectively (U.S. Army 2002a), the residual radiation dose to the resident farmer with loss of institutional controls would increase by less than 0.4 percent, a negligible increase. In terms of dose, a 0.4 percent increase equates to doses of less than 0.1 and 0.001 mrem/y (1×10^{-3} and 1×10^{-5} mSv/y) for Tc-99 and Pu-239/240, respectively. As such, the potential dose associated with these radionuclides is insignificant.

Computation of the peak dose over the 1,000-year period of interest resulted in an estimated maximum TEDE of 3.3 mrem/y (0.033 mSv/y) for sportsmen and NWR visitors in the event of loss of institutional controls. The TEDE, although fully protective with or without institutional controls being in place, is much lower than this value with institutional controls in place. As such, TEDE to sportsmen and NWR visitors is much lower than the 25 mrem/y (0.25 mSv/y) unrestricted release dose criterion contained in 10 CFR 20 CFR irrespective of the effectiveness or loss of institutional controls.

4.12.2.2.2 FWS and INANG Site Workers

Institutional controls addressed in the MOA (U.S. Army 2000a) necessitate that site personnel occasionally access the DU Impact Area for inspection or maintenance functions. These activities are expected to be of short duration and to exclude site remediation. To provide a conservative dose assessment for this scenario, a site worker is assumed to spend 2,000 hours (i.e., a full work year) outdoors in the DU Impact Area in the primary contamination zone. Pathways for this worker include external radiation, inhalation, and incidental soil ingestion. Drinking water is assumed to be obtained from a municipal drinking water source. The estimated peak annual dose for this site worker over the 1,000-year period of interest is 5.9 mrem/y (0.059 mSv/y) in the event of loss of institutional controls and is much lower with institutional controls in place.

The TEDE to sportsmen and visitors and to FWS and INANG site workers is very low relative to the dose standard of 25 mrem/y (0.25 mSv/y) mandated in 10 CFR 20.1402 and 10 CFR 20.1403 CFR for unrestricted and restricted release, respectively, and to the dose cited by NRC as the annual natural background dose to an individual (i.e., 310 mrem/y [3.1 mSv/y]) (http://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html).

4.12.2.2.3 Offsite Activities

DU could transport offsite in surface water flowing through the DU Impact Area. Environmental monitoring data collected semi-annually from December 2004 through October 2012 indicate that the total uranium concentrations in surface waters (i.e., Big Creek and Middle Fork Creek) that flow through the DU Impact Area range from 0.04 to 19 pCi/L with a mean concentration of 0.88 ± 2.4 pCi/L (error reported with 2 standard deviations). NRC has determined that a uranium concentration of 300 pCi/L corresponds to a dose of 50 mrem/y (0.5 mSv/y) if all drinking water is taken from a water source with that concentration (10 CFR 20, Appendix B). As such, based on these conservative assumptions, the highest and mean surface water concentrations (i.e., 19 and 0.88 pCi/L) would equate to doses of 3.2 and 0.15 mrem/y (0.032 and 0.0015 mSv/y), respectively.

Given the agricultural nature of the areas around JPG, the residual radiation dose to a resident farmer located at the boundary to the installation (i.e., about 1.9 mi [3 km] west of the DU Impact Area) was modeled. Pathways included in this scenario are:

- External exposure
- Incidental inhalation of dust containing DU
- Ingestion of crops, meat, and milk from livestock raised on the farm
- Drinking water from a surface water body located downstream from JPG
- Use of surface water downstream from JPG for irrigation of crops and consumption by livestock used for the production of milk and meat.

The TEDE to this resident farmer located at the boundary to the installation was determined to be 2 mrem/y (0.02 mSv/y).

4.12.2.2.4 Failure of Institutional Controls

Although institutional controls are used to restrict public access to areas north of the firing line that contain UXO and DU, a failure of these controls could occur. The hazard from a short-term failure of institutional controls, resulting in an individual spending time in the DU Impact Area, would be dominated by the UXO hazard that could lead to injury or death. With regard to radiological hazards associated with DU, as noted previously in this section, the TEDE in the event of loss of institutional controls equates to TEDEs of 3.3 and 5.9 mrem/y (0.033 and 0.059 mSv/y) for sportsmen and visitors and FWS/INANG site workers, respectively, and is much lower than this estimate if institutional controls remain effective.

In the event of loss of institutional controls, it is also possible that a resident farmer could construct a residence and implement subsistence farming on the DU Impact Area. As resident farmers would constitute the critical group, the TEDE for such a scenario was evaluated. This scenario was derived based on placement of a dwelling site 1,200 square yards (yd^2) (1,000 square meter [m^2]) inclusive of both the home and associated grounds on the contaminated area together with leafy vegetable garden 1,200 yd^2 (1,000 m^2), nonleafy vegetable and fruit garden 1,200 yd^2 (1,000 m^2), livestock grain fields 12,000 yd^2 (10,000 m^2), and livestock pasture/silage growing area 12,000 yd^2 (10,000 m^2) directly on the DU Impact Area. The following pathways for the resident are farmer included in the residual radiation dose assessment with additional details concerning uncertainties for these pathways being included in Appendix C of the Decommissioning Plan (U.S. Army 2013a):

- External exposure
- Incidental inhalation of dust containing DU
- Ingestion of crops, meat, and milk from livestock raised on the farm
- Drinking' water from a surface water body within the DU Impact Area located downstream from the trench
- Use of water from a groundwater well located on the DU Impact Area for use as a drinking water source and for irrigation of crops and consumption by livestock used for the production of milk and meat.

The TEDE to the resident farmer was determined to be 26.3 mrem/y (0.263 mSv/y). This dose is essentially indistinguishable from the 25 mrem/y (0.25 mSv/y) dose standard prescribed in 10 CFR 20.1402 for unrestricted release. If the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is ALARA and would not exceed 100 mrem/yr (1 mSv/yr) (or 500 mrem [5 mSv] with additional requirements). The peak annual doses over the 1,000-year period of interest for sportsmen and visitors and FWS/INANG site workers (i.e., the critical groups with institutional controls in place) equate to a maximum of only 3.3 mrem/yr (0.033 mSv/yr) and 5.9 mrem/yr (0.59 mSv/yr) in the event of loss of institutional controls. The respective TEDEs are much lower than the values with institutional controls in place; therefore, the DU Impact Area clearly complies with 25 mrem/yr (0.25 mSv/yr) dose standard mandated by 10 CFR 20 1403. In addition, the TEDE to the resident farmer, the critical group in the event of loss of institutional controls, equates to 26.3 mrem/y (0.263 mSv/y), is far below the dose standard of 100 mrem/y (1 mSv/y) prescribed in 10 CFR 20.1403 in the event of loss of institutional controls and is essentially indistinguishable from the unrestricted release dose limit of 25 mrem/y (0.25 mSv/y).

Uranium and thorium sites are generally required to implement and maintain durable and legally enforceable institutional controls and conduct 5-year reviews to ensure the institutional controls are in place and continue to function in accordance with NUREG 1757, Volume 1, Revision 2, Table M.1 (NRC 2006a). As shown in Table M.1, which is NRC'S risk-informed graded approach for institutional controls to restrict site use, "higher risk" sites include higher hazard levels (i.e., 100 to 500 mrem/y [1.0 to 5.0 mSv/y]) and longer-dose persistence or half-lives (i.e., greater than 100 years) because there is a higher likelihood of institutional control failure. However, the footnote to this table states that "It may be appropriate to treat sites with longer half-life radionuclide contamination, but with doses close to 25 mrem/y (0.25 mSv/y) assuming no controls, as 'Lower Risk' sites" presumably because the table includes a statement regarding the lower likelihood of institutional control failure. As such and given that the TEDE for the resident farmer (i.e., the average member of the critical group in the event of loss of institutional controls) in the DU Impact Area is essentially indistinguishable from the 25 mrem/y (0.25 mSv/y) unrestricted release dose standard, the Army, as an agency of the Federal Government and an enduring entity, proposes to manage the site as a "lower risk" site without conducting 5-year reviews.

4.13 WASTE MANAGEMENT IMPACTS

Under the No Action alternative, waste would not be generated or managed; therefore, no short- or long-term impacts are anticipated.

No waste would be generated, transported, or disposed of under the Proposed Action. Therefore, there would be no related impacts. UXO and DU currently located in the DU Impact Area would remain in place and be subject to the institutional controls in accordance with requirements in the ROD (U.S. Army 1996a), which states that "The Army will maintain and secure the property while in caretaker status" and the MOA (U.S. Army 2000).

5. MITIGATION MEASURES

The mitigation measures for the environmental impacts from implementing all reasonable alternatives, including Alternative 1, U.S. Nuclear Regulatory Commission (NRC) license continuation (No Action) (Section 5.1) and Alternative 2, NRC license termination under restricted conditions (Proposed Action) (Section 5.2), are described in this section. Mitigation measures are those measures taken to minimize adverse impacts or enhance beneficial impacts.

5.1 MITIGATION MEASURES FOR ALTERNATIVE 1: LICENSE CONTINUATION (NO ACTION)

The Army would continue to implement measures currently in place as caretaker of the portion of the facility north of the firing line; including retention of the NRC Materials License SUB-1435, implementing related monitoring and reporting requirements, and executing its responsibilities required in the Record of Decision (ROD) (U.S. Army 1996) and under the Memorandum of Agreement (MOA) (U.S. Army 2000a).

No adverse environmental impacts have been observed to date and are not anticipated in the future for the Depleted Uranium (DU) Impact Area, as summarized in Table 2-1 and Section 4. Beyond the Army continuing to implement measures consistent with its authority and responsibilities outlined in the MOA (U.S. Army 2000a), there would be no mitigation measures associated with this alternative. In addition, no residual impacts or unavoidable impacts were identified from the implementation of this alternative.

5.2 MITIGATION MEASURES FOR THE ENVIRONMENTAL IMPACTS OF ALTERNATIVE 2: LICENSE TERMINATION UNDER RESTRICTED CONDITIONS (PROPOSED ACTION)

Mitigation measures that could reduce the adverse impacts or enhance beneficial impacts are incorporated into the Proposed Action. The Army, as the responsible party for real property management and for unexploded ordnance (UXO), will continue to implement measures consistent with its authority and responsibilities outlined in the ROD (U.S. Army 1996a) and MOA (U.S. Army 2000a). These include, but are not necessarily limited to, maintaining fencing and perimeter warning signs, ensuring the gates on the perimeter fence surrounding the area north of the firing line remain pad locked, and executing other responsibilities specified in the MOA (U.S. Army 2000a). The U.S. Fish and Wildlife Service (FWS) and the Indiana Air National Guard (INANG) for the U.S. Air Force (USAF) will maintain institutional controls in accordance with the MOA to ensure the facility is secure and operated safely.

No adverse environmental impacts have been observed to date and are not anticipated in the future for the DU Impact Area, as summarized in Table 2-1 and Section 4. The Army has no plans to continue environmental monitoring or to conduct 5-year reviews after the license termination. Based on the lack of anticipated environmental impacts, no mitigative measures are needed for the Proposed Action. Beyond the Army continuing to implement measures consistent with its authority and responsibilities outlined in the ROD (U.S. Army 1996a) and MOA (U.S. Army 2000a), there would be no mitigation measures associated with this alternative. In addition, no residual impacts or unavoidable impacts were identified from the implementation of this alternative.

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