Safety Evaluation Report

For the U.S. Army's Possession Only License for Depleted Uranium Penetrator Rounds at Jefferson Proving Ground, Madison, Indiana

License No. SUB-1435
Amendment No. 20

Docket No. 040-08838

U.S. ARMY, ROCK ISLAND ARSENAL

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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Introduction

The U.S. Army (Army) submitted a license amendment request to the U.S. Nuclear Regulatory Commission (NRC) for license termination of Materials License No. SUB-1435 for the Depleted Uranium Impact Area (DU Impact Area) at the Jefferson Proving Ground (JPG) Facility in Madison, Indiana, under restricted conditions, dated August 28, 2013 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML13247A549). The license amendment request included a Decommissioning Plan (DP) and an Environmental Report (ER) (Army, 2013a; Army, 2013b). The proposed action at that time was the termination of NRC Materials License SUB-1435 with institutional controls for the DU Impact Area. The Army's basis for requesting restricted release was due to the hazardous and prohibitively expensive cleanup of the commingled depleted uranium (DU) and unexploded ordnance (UXO).

On November 25, 2015, the Army notified the NRC that it was withdrawing the DP and requested to have the NRC stop its action on the DP review (ADAMS Accession No. ML16005A100). The Army also stated that it would shortly be submitting a request for a license amendment to possess the material at the site in its current state without further decommissioning or remediation.

On December 21, 2016, the Army submitted a new license amendment request (ADAMS Accession No. ML17004A186) to change the authorized use of licensed material from "possession only for decommissioning" to "possession only" and to request an exemption from the NRC's decommissioning timeliness rule. The Army stated that a "possession only" license was preferable to a license terminated under "restricted release" due to feedback from public stakeholders, who were concerned that the Army would no longer be obligated to monitor groundwater for DU intrusion under a restricted release. The amendment request provides a new Decommissioning Funding Plan (DFP) and an Environmental Radiation Monitoring Plan (ERMP) for the DU Impact Area. The license amendment request also includes a detailed request and justification for an exemption from the NRC's Decommissioning Timeliness Rule. Specifically, the amendment request states "In accordance with 10 CFR 40.44, *Amendment of licenses at request of licensee*, the U.S. Army submits this request for exemption from 10 CFR 40.42 (Expiration and termination of licenses and decommissioning of sites and separate buildings or outdoor areas, timeliness condition specified in subparagraph d)."

By letter dated April 13, 2017, (ADAMS Accession No. ML17072A474), the staff informed the Army that it had accepted the license amendment request for detailed technical review. The staff sent the Army a request for additional information (RAI) on March 27, 2018 (ADAMS Accession No. ML17341B560). The Army responded to this request in a letter dated May 25, 2018 (ADAMS Accession No. ML18156A002).

This safety evaluation report (SER) summarizes the NRC staff's evaluation of the Army's December 21, 2016 license amendment request and supporting documents as they pertain to DU penetrator rounds.

Regulatory Requirements and Guidance

The Atomic Energy Act of 1954 (AEA), as amended, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 40.32, "General Requirements for Issuance of Specific Licenses," the NRC is required to make the following safety findings when

issuing a source materials license [or license amendment]: [1]

- The [amendment] application is for a purpose authorized by the [Atomic Energy] Act;
- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property;
- The applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property; and
- The issuance of the license [amendment] will not be inimical to the common defense and security or to the health and safety of the public.

This evaluation assesses the applicant's compliance with the requirements of 10 CFR Part 40, "Domestic Licensing of Source Material," as well as the applicable requirements of 10 CFR Part 20, "Standards for Protection Against Radiation." The NRC staff performed a review of the license amendment request and supporting materials using guidance in NUREG-1556, Volume (Vol.) 7, Revision 1, "Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Academic, Research and Development, and Other Licenses of Limited Scope Including Gas Chromatographs and X-Ray Fluorescence Analyzers" (NRC, 2018). This guidance document was used by the NRC staff because the NRC has no specific guidance for the possession of DU in the form of an unsealed source in the environment. While NUREG-1556, Vol. 7 explicitly states that it does not apply to source material (10 CFR Part 40) licensees, the NRC staff determined that this guidance is appropriate for determining whether the licensee meets the radiological protection requirements of 10 CFR Part 20 requirements at JPG. Of note, NUREG-1556, Vol. 7 was previously used in a similar application in the licensing for the U.S. Army's Source Materials License No. SUC-1593 for DU from M101 spotting rounds (ADAMS Accession No. ML18158A322).

With respect to the Army's requested exemption from the Decommissioning Timeliness Rule in 10 CFR 40.42(d), the staff considered the provisions of 10 CFR 40.14(a), "Specific exemptions", in that the request is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

Summary of NRC Staff's Findings

The NRC staff finds that the Army's license amendment request to change from "possession only for decommissioning" to "possession only" complies with the standards and requirements of the AEA and NRC regulations. In accordance with 10 CFR 40.32(a) and (d), the NRC staff finds that the Army is authorized to possess DU in the DU Impact Area and the issuance of this license amendment will not be inimical to the health and safety of the public.

In accordance with 10 CFR 40.32(b) and (c), the NRC staff finds that the Army is qualified by reason of training and experience to use source material for the purpose it requested, and that the Army's proposed equipment and procedures in the Radiation Safety Plan (RSP) (Army, 2018) are adequate to protect health and safety and minimize danger to life or property.

The license amendment would allow the Army to continue to conduct activities necessary for the possession and management of the DU penetrator rounds within the DU Impact Area. The

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[1] The requirements found in 10 CFR 40.32(e) through (g) do not apply in this instance as they pertain to uranium enrichment facilities, uranium milling, and production of uranium hexafluoride."

license amendment would prohibit the Army from performing decommissioning or ground disturbing activities to collect or remove DU fragments or contaminated soil that is identified during range activities without prior authorization from the NRC. The Army's RSP states that picking up incidental pieces of DU found onsite would be allowed without further NRC approval, if it does not involve ground disturbing activities (Army, 2018).

Based on the results of the site-specific modeling, the NRC staff has verified that the Army is in compliance with 10 CFR 20.1301(a) and (d), 20.1302(a) and (b), 20.1501, 20.2001(a), and 20.2103(b) for the DU Impact Area.

In addition, the NRC has determined that the requested exemption from the Decommissioning Timeliness Rule[2] is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest. The NRC will provide this license renewal for a 20-year period. Prior to expiration of the license, in accordance with 10 CFR 40.42(a), the Army must apply for a renewal of the license and determine if any technological developments will make decommissioning the site feasible at some future date. Under the possession-only approach, the Army will be required to maintain the license, site conditions, environmental monitoring, and security. Staff proposes to add license condition 14 to License No. SUB-1435 to provide the exemption from the Decommissioning Timeliness Rule. The NRC staff also proposes license condition 15 to be included in the license to specify the Army's environmental monitoring commitments and license condition 16 to specify the need for the Army to maintain site conditions, fencing, postings, and security and that the U.S. Fish and Wildlife Service (FWS) and the U.S. Air Force (Air Force) may meet these requirements on behalf of the Army in accordance with current Memorandums of Agreement (MOA), which the Army will provide to the NRC.

The staff has also concluded that it is acceptable, as requested by the Army in the license amendment request, to modify the license conditions, in part, as follows:

- Under Authorized Place of Use, to remove provision 10.B related to license transfer from Aberdeen Proving Ground to the Rock Island Arsenal – in that the transfer previously occurred and the information is already captured under Item 2 of the license.
- Under Conditions, to modify License Condition 12.D related to the JPG Security Plan – and note that it has been superseded by the current RSP, dated May 22, 2018 (ADAMS Accession No. ML18156A002). License Amendment 18, dated November 5, 2013 (ADAMS Accession No. ML13291A307), previously authorized the RSP to replace the JPG Security Plan, as documented in the Amendment 18 SER, ADAMS Accession No. ML13291A321).[3]

[2] The Army has requested an exemption to 10 CFR 40.42(d), which states, in part, "within 60 days of permanently ceasing operations the licensee shall notify the NRC and begin decommissioning its site or submit within 12 months of notification a decommissioning plan." The NRC exemption will actually be under 10 CFR 40.42(h)(1), which states, in part, "the licensee shall complete decommissioning of the site as soon as practicable but no later than 24 months following initiation of decommissioning."

[3] Staff notes that it incorrectly issued two versions of License Amendment 18, the second is dated November 30, 2016, (ADAMS Accession No. ML16292A399). The second Amendment 18 inadvertently overwrote License Conditions 12.H that in the first Amendment 18 (ADAMS Accession No. ML13291A307) referenced the new RSP as superseding the Security Plan.

- Under Conditions, to delete License Condition 13 related to submitting a decommissioning plan and environmental report by August 2013– the dates in this condition have already passed and the condition is no longer applicable.

Background

JPG is located in southeastern Indiana and was established in 1940 by the U.S. War Department and operated from 1941-1995. JPG's primary mission was to support research, tests, and operations of the Army. JPG tested production and post-production conventional ammunition components, other ordnance items, and propellant ammunition/weapons systems and components. From 1941-1995, over 24 million rounds of conventional explosive ammunition were fired at JPG.

From 1984-1994, JPG test fired 100,000 kg [220,462 lbs.] of tank penetrator rounds containing DU under NRC License SUB-1435. The DU Impact Area is approximately 518 hectares [1280 acres] and north of the firing line. After several operations to recover DU, the impact area still contains about 73,500 kg (162,000 lbs) of DU and 1.5 million rounds of UXO. Since 1984, the soil, groundwater, surface water, and sediment have been monitored for DU at least semi-annually.

Figure 1-1. DU Penetrator Round

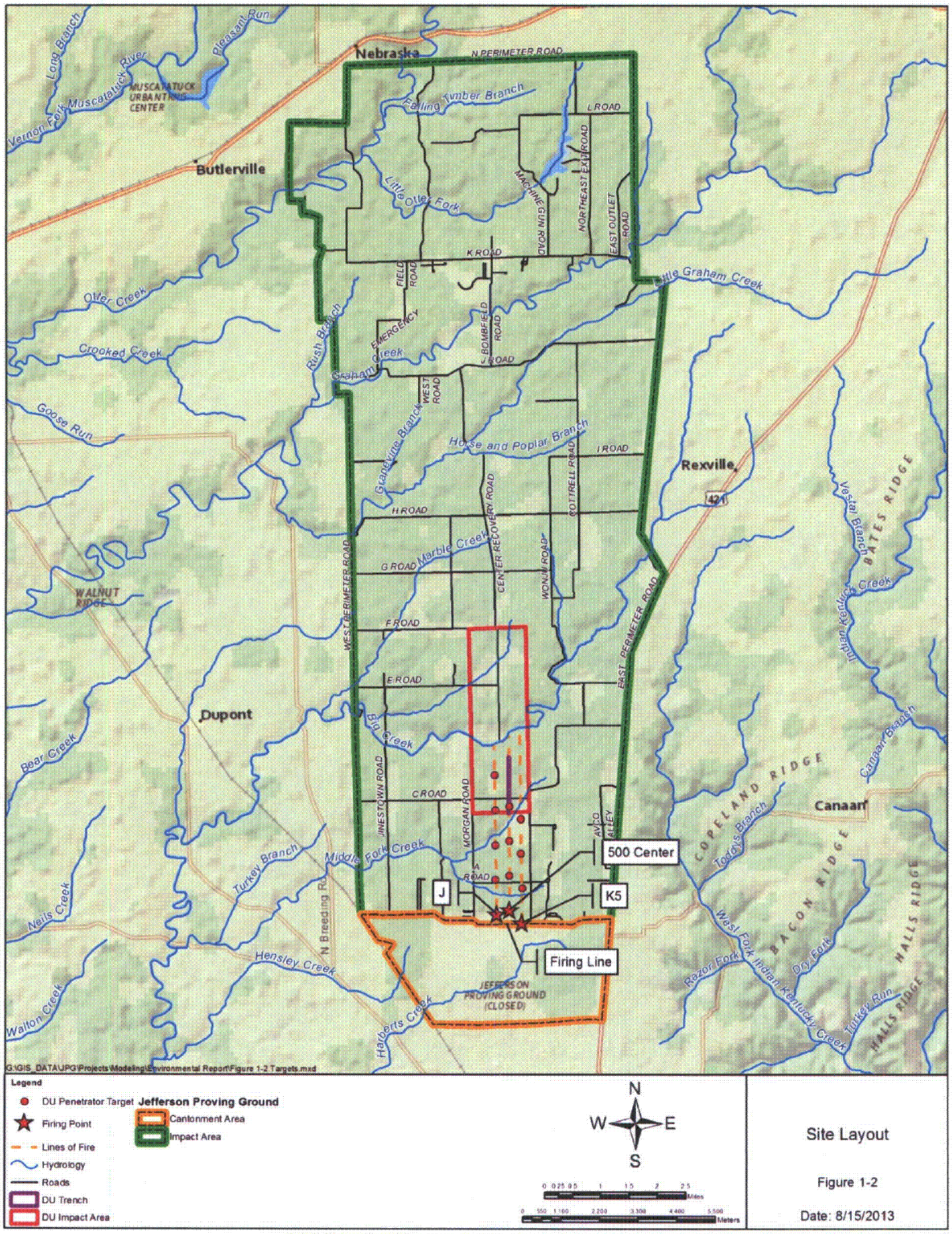

Figure 1-2. JPG Firing Range

As a result of the Base Closure and Realignment Act (BRAC) of 1988, the Army's mission at JPG terminated in September 1995 and was relocated to the U.S. Army Yuma Proving Ground in Arizona. Also, in September 1995, the Army requested to transfer the NRC license from JPG to the U.S. Army Test and Evaluation Command (Army), Aberdeen Proving Ground, Maryland. Buildings and areas in the southern cantonment area were then decommissioned, and some of the DU and other wastes were removed to appropriate licensed disposal sites. In 1996, the NRC approved the license transfer, amended the license to possession only of DU north of the firing line, and released the cantonment area for unrestricted use.

In 1997, a MOA was established between the Army and the FWS to develop an ecosystem-based plan for the 20,640 hectares [51,000 acres] northern firing range area. In 1998, a Memoranda of Understanding (MOU) was signed by the Army, the Air Force, and the Indiana Air National Guard (INANG). The MOU states that, in exchange for continued use of the 418 hectare [1,033 acre] bombing range, INANG would maintain and operate the northern firing range area north of the DU Impact Area.

The 1997 MOA was superseded by a May 2000 MOA signed between the Army, the Air Force, and the FWS. The MOA authorized future use by FWS and continued use by the Air Force of the firing range for 25 years, with 10-year extensions thereafter. Due to UXO, DU, and other environmental contamination from past Army activities, the firing range is not suitable for commercial or residential development, however, part of it contains wildlife habitat of regional and national significance.

In June 2000, the FWS established the Big Oaks National Wildlife Refuge. Activities at the bombing range have had no known significant adverse impact on the wildlife at the firing range area, and the Air Force will continue to use the bombing range as a training facility. Under the MOA, the Air Force and FWS share responsibilities for infrastructure maintenance north of the firing line.

The presence of UXO, the associated risk of potential explosions, and the high cost for cleanup complicate remediation activities in the north area. A DP was submitted by the Army in 1999 (ADAMS Accession No. ML993300036) and later withdrawn in 2001 when a new DP was submitted (ADAMS Accession No. ML011800338). The NRC staff rejected the 2001 DP after an expanded acceptance review noted several deficiencies, particularly the need for off-site transport models. The Army submitted a revised DP in 2002 (ADAMS Accession No. ML021930415). However, the Army withdrew the revised 2002 DP and, in 2003, requested that the possession-only license be issued for a 5-year renewable period indefinitely. The Army needed to obtain site-specific data to validate the off-site transport models. SECY-03-0031, dated March 3, 2003 (ADAMS Accession No. ML023430018) informed the Commission that, because of unique conditions at the JPG site, the staff intended to allow the licensee to indefinitely delay decommissioning and continue the possession-only license currently in effect at the site.

Subsequently, the Army began various studies aimed towards decommissioning the area and to validate the off-site transport models with site-specific data. These studies included leachate/corrosion studies, groundwater age dating, aquifer parameters, electrical imaging, radiation monitoring, computer modeling, and soil, surface water, and sediment analyses.

Following these additional studies, the Army submitted a license amendment request, dated August 28, 2013, to the NRC, which included a revised DP and an ER (ADAMS Accession No. ML13247A549). The Army submitted the DP and ER in support of its request that the NRC

terminate Materials License SUB-1435 for the DU Impact Area at JPG, under restricted conditions.

Following this 2013 submittal, the NRC staff began the safety and environmental review of the DP. A set of RAIs to address remaining issues that the staff needed further information from the licensee was sent in December 2015 and a follow up meeting/teleconference was scheduled in January 2016. Prior to the scheduled RAI discussion meeting, a staff member of the Rock Island Arsenal Commander notified the NRC staff that he saw no reason to have the RAI discussion since the Army had already requested withdrawal of the DP in a letter dated November 20, 2015.[4]

The Army informed the NRC that the reasons for the DP withdrawal were feedback from the community regarding the uncertainty of continued monitoring of the effluents from the site and the Army's continued responsibility for the site. This public community concern led to the current license amendment request (ADAMS Accession No. ML17004A186) that the Army submitted in December 2016, to change the authorized use of licensed material from "possession only for decommissioning" to "possession only" and to request an exemption from the NRC's decommissioning timeliness rule.

Safety Evaluation

1.0 Authorized Use and Exemption from 10 CFR 40.42(h)(1)

1.1 Regulatory Requirements

Section 40.3 of Title 10 of the Code of Federal Regulations (CFR) establishes the requirements for NRC to issue a license and states, "a person subject to the regulations in this part may not receive title to, own, receive, possess, use, transfer, provide for long-term care, deliver or dispose of byproduct material or residual radioactive material as defined in this part or any source material after removal from its place of deposit in nature, unless authorized in a specific or general license issued by the Commission under the regulations in this part." The Army has been authorized to possess DU since the initial licensing of the material in 1984 under Materials License No. SUB-1435.

Section 40.14 of Title 10 of the CFR establishes the requirements for the Commission to grant specific exemptions and, in pertinent part, states:

> [t]he Commission may, upon application of any interested person…, grant such exemptions from the requirements of the regulation in [10 CFR Part 40] as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

1.2 Regulatory Acceptance Criteria

The amendment application was reviewed for compliance with the applicable requirements of 10 CFR 40.31, "Application for specific licenses" and 10 CFR 40.32, "General requirements for issuance of specific licenses."

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[4] This letter was lost due to misaddressing and finally arrived via email in January 2016 in which the Army notified the NRC that it wished to withdraw the DP and have the NRC stop its action on the DP review.

1.3 NRC Staff Review and Analysis

The NRC staff reviewed the Army's license amendment request for the proposed use of DU in accordance with the applicable requirements of 10 CFR 40.31, using the guidance in Item 6, "Purpose for Which Licensed Materials Will Be Used," of NUREG-1556, Vol. 7 (NRC, 2018). The staff review focuses on whether the activity is authorized by the AEA and that the Army clearly specified the purpose of use with a description detailed enough to allow the NRC to determine the potential for exposure to radiation and radioactive materials to those working with radioactive materials and to members of the public. In this case, the Army has been authorized to possess this material since the initial licensing of the material in 1984 under NRC License SUB-1435.

The Army's proposed use at JPG is for "possession only". The Army defined "possession only" to mean "residual radioactive exists in place and administrative controls are maintained to minimize exposure to the public and the environment."[5] The JPG site is now located within the FWS Big Oaks National Wildlife Refuge, and the Army's DU is contained in the DU Impact Area, which is a restricted area inside of the National Wildlife Refuge. This area is located north of the firing line in a restricted range area at JPG. The license amendment request, combined with the 2015 application, provides a description of the methods that the Army used to estimate the type of material, its chemical and physical form, and the mass of DU at the DU Impact Area is reasonable. These documents also describe the Army's dose modeling approach.

The staff reviewed the Army's justification for a specific exemption from 10 CFR 40.42(h)(1). The Army's justification focuses on certain decommissioning timeliness concerns articulated in NRC Administrative Letter 96-05, "Compliance with the Rule 'Timeliness in Decommissioning of Material Facilities" (ADAMS Accession No. ML081570203), specifically, safety practices becoming lax once operations cease and the potential for bankruptcy. The Army also considers whether the request endangers life, property, or common defense and security and is otherwise in the public's best interest.

The staff considers the continued oversight by the Army under this license amendment will be sufficient to ensure appropriate safety practices will continue at JPG. Because of the unique nature of the "possessed" material, the use of a portion of the DU Impact Area as a bombing range, and because the entire DU Impact Area (and bombing range) resides within the National Wildlife Refuge, the staff considers an MOA appropriate for oversight of the site as it defines responsibilities of each party (the Army, FWS, and the Air Force). Each entity has a role in access control, maintenance and upkeep, and responding to UXO, DU and other environmental contamination. Further, the MOA identifies how the Army will reimburse the other parties for certain site-related expenses.

As discussed in Section 5.0 of this SER, the Army provided a Statement of Intent (SOI) as a means of financial assurance of decommissioning activities. As discussed in Sections 3.0 and 4.0, the Army commits to performing continued environmental monitoring to ensure that operations will not endanger life and property. Given the hazardous and prohibitively expensive cleanup cost of the commingled DU and UXO, as well as public concerns, the Army determined that continued possession of the DU material is in the public interest. The license renewal will be for a 20-year period and then re-evaluated at that time to determine if any technological

[5] Section 1.1.5 of the (revised) Radiation Safety Plan for Jefferson Proving Ground Depleted Uranium Impact Area, dated May 22, 2018, states the license continuation as "possession only".

developments will make decommissioning the site feasible at a future date.

1.4 Evaluation Findings

As this amendment represents a change from possession only for decommissioning to possession only, it continues to be authorized by the AEA. Furthermore, the staff concludes the methods that the Army used to estimate the type of material, its chemical and physical form, and the mass of DU at the JPG DU Impact Area are reasonable. From 1984 – 1994 the Army test fired 100,000 kg (220,000 lbs) of tank penetrator rounds containing DU into the DU Impact Area north of the firing line. After several operations to recover DU, the DU Impact Area still contains about 73,500 kg (162,000 lbs) of DU. Because the DU range also contains UXO, the NRC staff believes it is not necessary to identify the exact location of every DU penetrator round within the DU Impact Area.

In SECY 19-0001, "Jefferson Proving Ground Request for Possession-only License Amendment and Exemption from Decommissioning Timeliness Rule," dated December 31, 2018, the NRC staff informed the Commission of the Army's request for a possession-only license amendment and exemption from the decommissioning timeliness rule. The SECY paper notes that the 10 CFR 40.42(h)(1) exemption was requested by the Army because the "possession only" license was preferable to a license terminated under "restricted release" due to feedback from the public stakeholders, who were concerned that the Army would no longer be obligated to monitor groundwater for DU intrusion under a restricted release.

The NRC staff review of the Army's dose modeling approach and technical basis for the dose modeling is presented in Section 3.0 of this SER. The NRC staff review of the Army's ER (Army, 2013b) and the Army's DP (Army, 2013a) for potential significance of any transport of DU contamination outside of the designated DU Impact Area, as well as the environmental monitoring commitments in the Army's ERMP is presented in Section 4.0 of this SER.
Based on these reviews, the NRC staff finds that the information in the Army's license amendment request, along with the supporting RSP discussed herein, represent acceptable documentation to comply with 10 CFR 40.31.

In conclusion, the NRC staff finds the Army's request for exemption from the decommissioning timeliness rule in 10 CFR 40.42(h)(1) is acceptable in that it is authorized by law, will not endanger life or property or the common defense and security, and is otherwise in the public interest. However, the Army continues to be required pursuant to 10 CFR 40.36(d)(2), "At the time of license renewal and at intervals not to exceed 3 years, the decommissioning funding plan must be resubmitted with adjustments as necessary to account for changes in costs and the extent of contamination." As discussed in in Section 5.3 of this SER, the DFP included in the Army's amendment request states that they will evaluate and adjust the decommissioning cost estimates on a 3-year cycle to ensure costs accurately reflect changes in: material inventory and possession limits; contamination of applicable environmental media; facility modifications; remediation costs; and disposal costs.

2.0 Radiation Safety and Security Program

As the license amendment request is to change the authorized use from "possession only for decommissioning" to "possession only", the "in effect" RSP was not included nor required to be included in the amendment request. However, the staff performed a review of the existing June 21, 2013 RSP (ADAMS Accession No. ML13191A824) to ensure the scope of activities

at JPG would be limited to “possession-only” without the opportunity for decommissioning and determined that the scope of activities needed to be modified to reflect the change in scope of the radiation safety program. Based on this review, the staff developed a RAI (ADAMS Accession No. ML17341B560) requesting that the Army submit an updated RSP to support the 2016 license amendment request to change the authorized use to possession only. Staff noted that the RSP the Army submitted June 21, 2013, stated under Section 1.1.5, License Termination, that the Army proposes to terminate its NRC license with Restricted Use for the DU Impact Area.

In response to the staff’s RAI (ADAMS Accession No. ML17341B560) on the RSP, the Army submitted a revised RSP dated May 22, 2018 (ADAMS Accession No. ML18156A002). The staff confirmed the change in Section 1.1.5, “License termination,” to “License continuation as ‘possession only;” is defined as follows:

> The US Army proposes to continue its NRC license as “possession only” for the DU impacted area. “Possession only” means residual radioactive material exists in place and administrative controls are maintained to minimize exposure to the public and the environment.

As the Army discusses in the revised RSP, the statement above defines the requested authorized use for NRC License No. SUB-1435. The NRC staff confirmed that the remainder of the revised RSP is consistent with the previously approved RSP, which in accordance with Amendment 18 to SUB-1435, dated November 5, 2013 (ADAMS Accession No. ML13291A307), previously authorized the RSP to replace the JPG Security Plan (as documented in the Amendment 18 SER, ADAMS Accession No. ML13291A321).

As part of its review, the staff highlights the following portions of the revised RSP. The Army has designated the US Army Garrison Rock Island Arsenal Commander or Manager as the licensee (certifying official) for the NRC Materials License No. SUB-1435 and will notify the NRC of any changes in command. This notification is an administrative notice and does not require prior NRC approval. The RSP designates a License Radiation Safety Officer (LRSO) as a direct report to the garrison commander or manager. The LRSO also is the NRC point of contact for ensuring compliance with the NRC regulations and license conditions. The current LRSO is Dr. Robert Cherry. While License No.SUB-1435 allows the Army to replace the LRSO without prior approval of the NRC, best practice by the NRC identifies the LRSO on the license. To implement this practice, Amendment 20 will specifically identify the current LRSO on the license.

No Form 313 will be required for a change in certifying official or a change in LRSO for License No. SUB-1435. The Army may communicate a change in certifying official via a letter that the NRC staff will add to the license docket. The Army may communicate a change in LRSO via a notification letter including the required training and experience documentation to support the LRSO change that the NRC staff would add to the license docket. On a notification of change in LRSO, the NRC staff will issue an administrative amendment to the license (see Section 6.0 for license conditions).

In addition, Section 15, “Radioactive Material and Access Control,” of the RSP, describes physical access controls in the form of perimeter fencing maintained under the MOA by INANG (acting on behalf of Air Force), as well as, the role of FWS, under the MOA, to control public access to the refuge and monitor visitor ingress and egress.

In conclusion, as the activities associated with possession of the DU material are more limited under “possession only” than “possession for decommissioning”, the NRC staff find the revised RSP to be acceptable.

3.0 Dose Assessment

In support of the staff’s determination related to “Authorized Use” and consideration of the licensee’s requested exemption from the decommissioning timeliness rule, staff reviewed the dose analyses originally performed to support the DP (Army, 2013a), including analyses for an industrial worker, a sportsman / recreationalist, and a hypothetical resident farmer in the DU Impact Area.[6] In addition, the license amendment request and associated responses to an NRC RAI included a dose analysis for a hypothetical individual who takes a penetrator from the site, cleans corrosion products off the penetrator, and is subsequently exposed to it while working in a workshop where it is stored (i.e., the “souvenir hunter” scenario). The Army used those four dose analyses, in combination with a proposal to monitor uranium concentrations in groundwater, as part of the demonstration that the dose limits for members of the public would be met.

In the license amendment request, the Army did not include a separate dose projection to demonstrate that occupational exposures would be within regulatory limits. Although the Army’s analysis considers the FWS and INANG workers in the context of the public dose limits, the NRC staff determined that the modeled exposure time in the DU Impact Area also made the results relevant to occupational exposures. Therefore, the NRC staff evaluated the Army’s projected dose to an onsite industrial worker, in addition to additional information about external exposure from contact with DU, to evaluate compliance with occupational dose limits.

3.1 Regulatory Requirements

- 10 CFR Part 20, Subpart B, “Radiation Protection Programs”: 10 CFR 20.1101(d) constrains air emissions of radioactive material to the environment, excluding Radon-222 and its daughters, to 0.1 mSv/yr (10 mrem/yr) for all types of NRC licensed facilities except those subject to 10 CFR 50.34a (considered ALARA)

- 10 CFR Part 20, Subpart C, “Occupational Dose Limits”: 10 CFR 20.1201 – 1208 provides occupational dose limits, radiation exposure requirements, and information on dose limits to an embryo/fetus

- 10 CFR Part 20, Subpart D, “Radiation Dose Limits for Individual Members of the Public”: 10 CFR 20.1301 – 1302 establishes the dose to the public from licensed material

- 10 CFR Part 40, “Specific Exemptions”: 10 CFR 40.14 requires that specific exemptions from Part 40 are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

[6] The DP (Army, 2013a) included dose analyses for additional scenarios, such as a farmer at the boundary of the JPG site; however, that analysis was not referenced in the license amendment request.

3.2 NRC Staff Review and Analysis

The NRC staff reviewed the dose analyses for four exposure scenarios that the Army cited in its license amendment request (i.e., an industrial worker, a sportsman / recreationalist, a hypothetical resident farmer in the DU Impact Area, and a souvenir hunter). The NRC staff reviewed the Army's dose analyses in accordance with the guidance in NUREG-1556, Vol. 7. The staff used Appendix K, "Public Dose," and Appendix M, "Radiation Safety Survey Topics."

3.2.1 Compliance Approach

The NRC regulation at 10 CFR 20.1302 states that a licensee must show compliance with the annual dose limit for individual members of the public by:

- demonstrating by measurement or calculation that the total effective dose equivalent (TEDE) to the individual likely to receive the highest dose, in an unrestricted area from licensed operations, does not exceed 1 mSv [100 mrem] in a year; or
- demonstrating that the annual average concentration of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area does not exceed the values specified in Table 2, "Effluent Concentrations," of Appendix B to 10 CFR Part 20; and
- demonstrating that if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.02 mSv [2 mrem] in any 1 hour and 0.5 mSv [50 mrem] in a year

The Army used a combination of dose modeling analyses and a proposal to monitor uranium concentrations in groundwater and surface water to meet these requirements.

The Army used mathematical models to demonstrate compliance with the 10 CFR 20.1101(d) ALARA constraint on the dose from air effluents, the 10 CFR Part 20 Subpart C occupational dose limits, the 10 CFR 20.1301(a)(2) limit on external exposure, and the 10 CFR Part 20 Appendix B limits on air effluents. To address the 10 CFR Part 20 Appendix B liquid effluent limits, the Army proposed to monitor groundwater and surface water at the site. The Army used a combination of dose models and proposed groundwater monitoring to demonstrate compliance with the 10 CFR 20.1301(a)(1) 1 mSv/yr (100 mrem/yr) TEDE public dose limit. The Army relied on the results from all of those assessments to demonstrate compliance with the requirements of 10 CFR 20.1302 listed above and to demonstrate that the specific exemption from 10 CFR Part 40 requested to change License No. SUB-1435 from "possession only for decommissioning" to "possession only" would not endanger life, in partial fulfillment of the requirements of 10 CFR 40.14.

In the license amendment request, the Army relied on several projected doses that the Army had originally included in its 2013 DP. Specifically, in the license amendment request, the Army relied on projected doses to an industrial worker, sportsman / recreationalist, and onsite resident farmer as part of the demonstration that the regulatory requirements listed in Section 3.1 will be met. The results from the Army's 2013 DP that the Army relied on in the license amendment request are summarized in Table 3-1 below.

The projected doses summarized in Table 3-1 represent the peak of the mean results from a probabilistic analysis. Section 3.2.4 describes how the Army evaluated whether an appropriate

number of realizations were run and Section 3.2.10 describes which parameters the Army represented probabilistically. The NRC staff finds the use of the peak of the mean of the realizations to be an acceptable way to characterize the results of the model runs. For the onsite souvenir hunter, the Army used a combination of hand calculations and deterministic model runs. The NRC staff finds the use of deterministic analyses to be acceptable if parameters to which the projected dose is sensitive are well supported with data or are based on conservative choices, which the NRC staff found to be true in these analyses.

Table 3-1. Projected Doses Reported in the Army's License Amendment Request for a Possession Only License and Exemption from the Decommissioning "Timeliness Rule."

Scenario	Projected Dose [a] (mrem/y)	Calculation Method(s)	Original [b] Reference
Sportsman / Recreationalist	3.3	RESRAD-Offsite (Version 2.6)	DP Table 4-1 (Army, 2013a)
Industrial Worker (FWS and INANG workers)	5.9	RESRAD-Offsite (Version 2.6)	DP Table 4-1 (Army, 2013a)
Onsite Residential Farmer (in DU Impact Area)	26	RESRAD-Offsite (Version 2.6)	DP (Army, 2013a)
Souvenir Hunter (revised)	67	RESRAD-Build (Version 3.5) and hand calculations	RAI response (Army, 2018)

[a] To convert mrem/yr to mSv/yr, divide by 100.
[b] The doses provided in this table all were reported in the Army's license amendment request. However, the Army had previously reported three of these projected doses the DP (Army, 2013). For each projected dose, this table provides the reference where the Army provided its detailed analysis.

The projected dose for the onsite resident farmer in Table 3-1 includes the projected dose from groundwater pathways (e.g., drinking contaminated groundwater, ingesting plants contaminated by irrigating with contaminated groundwater). However, in response to several NRC questions about the Army's modeling of DU transport in groundwater (NRC, 2015), the Army indicated that it would rely on groundwater monitoring rather than groundwater modeling as part of the demonstration of compliance with the dose limits (Army, 2018).

The Army's Standard Operating Procedure for environmental monitoring (Army, 2000) establishes an action level of 5.55 Bq/L (150 pCi/L) for U-238, U-235, and U-234, applied as a sum of fractions, in groundwater or surface water. That concentration represents half of the 10 CFR Part 20 Appendix B effluent limits for those radionuclides. As explained in 10 CFR Part 20 Appendix B, those effluent limits were based on a projected dose of 0.5 mSv/yr (50 mrem/yr) TEDE for an individual whose annual water intake comes from the contaminated water source (i.e., groundwater, surface water, or a combination of both). The technical basis for the effluent limits did not include other water-based pathways, such as consumption of plants contaminated by irrigation with contaminated water. Therefore, to assess the potential dose contributions from groundwater-dependent pathways in the unexpected case that the uranium concentrations reached the 10 CFR Part 20 Appendix B effluent concentration limits, the NRC staff conducted

an independent analysis (see Section 3.2.8). That analysis demonstrated that, for the JPG site, if the groundwater concentrations of U-238, U-235, and U-234 meet the 10 CFR Part 20 Appendix B liquid effluent limits, applied as a sum of fractions, the site is expected to meet the 10 CFR 20.1301(a)(1) 1 mSv/yr (100 mrem/yr) TEDE public dose limit.

As discussed in Section 3.0, the Army did not provide a separate dose analysis to demonstrate compliance with occupational dose limits. Occupational exposures will be governed by the RSP, which is discussed in Section 2.0. In addition, the NRC staff evaluated the Army's projected dose to an onsite industrial worker in the context of both occupational and public dose limits, although the Army only discussed that dose projection in the context of the public dose limits. The NRC staff also evaluated additional information about external exposure from contact with DU, which presented by the Army in the context of the souvenir-hunter scenario, in the context of potential occupational exposures. The NRC found that the information provided by the Army to demonstrate compliance with the regulatory requirements listed in Section 3.1 is acceptable because the proposed combination of dose models and environmental monitoring addressed all of the relevant exposure pathways.

3.2.2 Source Term

3.2.2.1 Characterization of Radionuclides

The radioactive source term in the DU Impact Area at the former JPG site is military DU. Therefore, the principle radionuclides of concern are U-238, U-235, and U-234. If the feed for the uranium enrichment process that created the DU was contaminated with reprocessed fuel, the resulting DU can also contain small amounts of technetium-99 (Tc-99), U-236, and transuranic radionuclides. Based on information from the Department of Energy, the Army determined that the DU is expected to contain less than 3 pCi/g of Pu-239/240 and less than 400 pCi/g of Tc-99 (Army, 2002).

For the onsite resident farmer scenario, the Army used a separate deterministic RESRAD-Offsite (Version 2.6) model to calculate projected doses from Tc-99 and Pu-239/240. The Army found that the projected dose would be less than 1 x 10^{-3} mSv/yr (0.1 mrem/yr) from Tc-99 and 0.001 mrem/yr from Pu-239/240 (i.e., less than 1 percent of the projected dose from U-238, U-235, and U-234). Based on this low projected dose, the Army excluded these radionuclides from further analysis. The NRC staff reviewed the deterministic RESRAD-OFFSITE runs, including parameters specific to Tc-99 and Pu-239/240 (e.g., sorption coefficients), and determined that the model was appropriate for projecting doses from Tc-99 and Pu-239/240. Therefore, NRC staff determined it was acceptable to exclude Tc-99 and Pu-239/240 from detailed analysis in the onsite resident farmer scenario because the very low projected doses from those radionuclides would not affect the compliance demonstration. Because the dose to a hypothetical onsite resident farmer bounded the projected doses to the onsite industrial worker and sportsman / recreationalist (see Section 3.2.3.1), and because those scenarios do not contain any exposure pathways that make them more sensitive to Tc-99 or Pu-239/240, the NRC staff also determined that it was appropriate to exclude those radionuclides from further analysis in the other onsite scenarios.

For the souvenir hunter scenario, the Army did not evaluate the potential impact from Tc-99 and Pu-239/Pu-240. To address the issue, the NRC staff evaluated the relative concentrations and dose conversion factors (DCFs) for inhalation, ingestion, and direct radiation and determined that the impurities would be expected to cause less than one percent of the dose caused by U-238, U-235, and U-234 in the souvenir hunter scenario. Therefore, the NRC staff determined

that it is appropriate to exclude Tc-99 and Pu-239/240 from further analysis in the souvenir hunter scenario.

The Army stated that military DU typically has a specific activity of 1.2×10^{-2} MBq/g (3.42×10^{-7} Ci/g) (Army, 2013a). However, in calculating its radiologic source term from the mass of DU left at the site, the Army used a specific activity of 1.3×10^{-2} MBq/g (3.6×10^{-7} Ci/g), which is the value specified in 10 CFR 20, Appendix B if a specific activity associated with an express combination of uranium isotopes is not used. That specific activity represents a mass-based distribution of 0.0010 percent U-234, 0.200 percent U-235, and 99.7990 percent U-238. The NRC staff finds this approach acceptable for evaluation of radiological exposure and dose limits because using the specific activity given in 10 CFR 20 Appendix B to convert the mass-based source term into radiologic units results in a larger radiologic source term than using the ratio typical of Army DU.

3.2.2.2 Mass and Spatial Distribution of Penetrators

There is approximately 73,500 kg (162,000 lbs) of DU at JPG. The penetrators are mostly spread within the 8.4 km^2 (2,080 acre) DU Impact Area, however, some penetrators are expected to have ricocheted into the surrounding area such that the Army expects the penetrators to be located within an area of 15.6 km^2 (3,844 acres). The DU is spread unevenly over the area. It is focused along the 500 Center Firing Line in trench formed by the impact of the penetrators. In the RESRAD-Offsite models, that distribution was approximated with a “primary contamination zone” (PCZ) approximating the more concentrated contamination along the line of fire, and a less contaminated “secondary contamination zone” (SCZ) on either side of the primary contamination area (see Table 3-2 and Figure 3-1).

Table 3-2. Modeled Primary and Secondary Zone Depleted Uranium Concentrations Jefferson Proving Ground, Madison, Indiana. (Reproduced from Table 3-2 of Appendix C of the DP [Army, 2013a])

Radionuclide	PCZ (pCi/g)	SCZ (pCi/g)
U-234	22.3 to 77	1.3 to 4.3
U-235	1.6 to 5.4	0.1 to 0.3
U-238	124.9 to 416.4	6.9 to 22.9

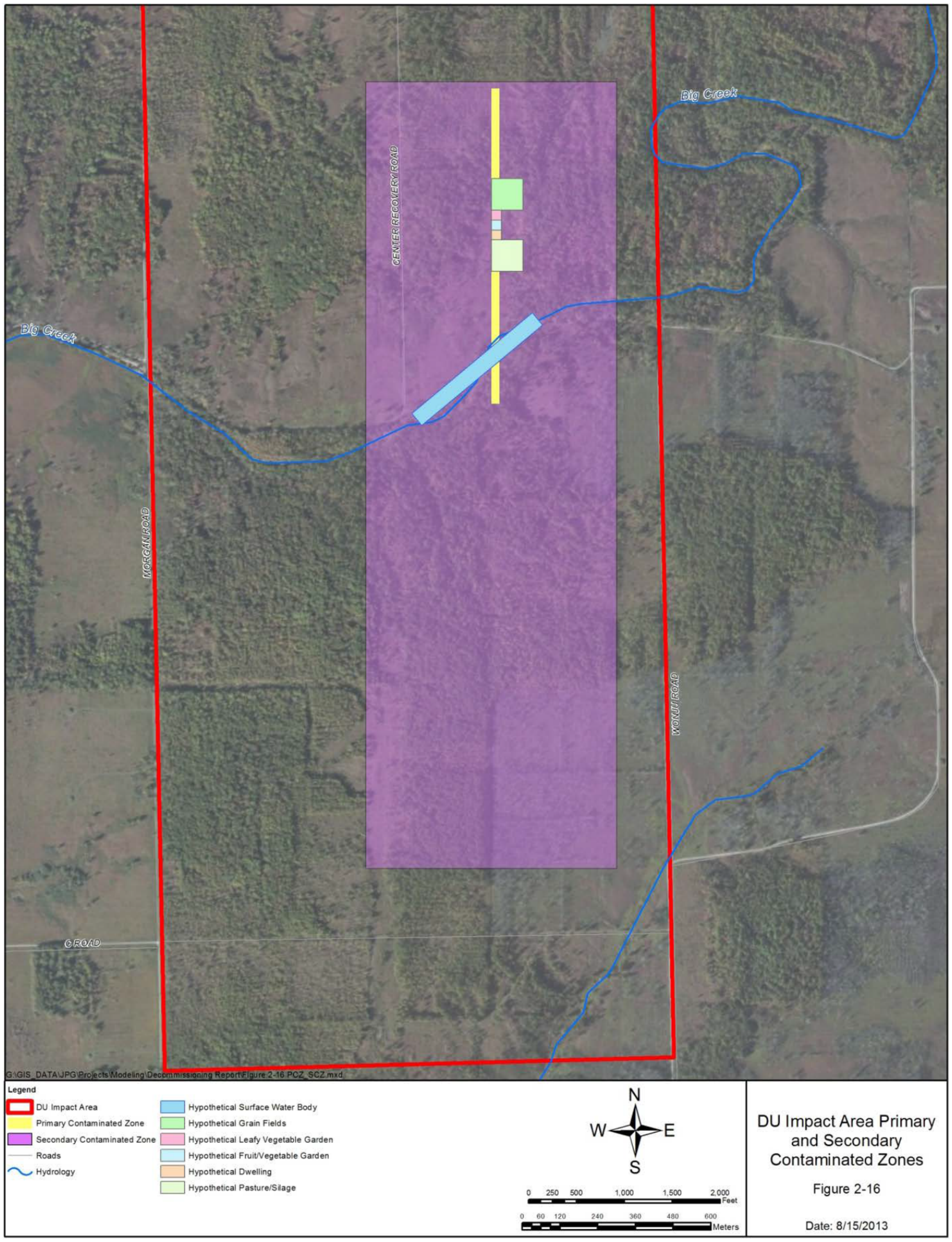

Figure 3-1. Diagram of the main features of the Army's RESRAD-Offsite analysis including the PCZ (yellow area) and SCZ (purple area). Reproduced from Figure 2-16 of the DP (Army, 2013a).

In addition to being spread over the DU Impact Area, the penetrators are also distributed vertically in the soil. The Army has measured evidence of DU contamination up to 1.4 m (4.5 feet) below the ground surface at locations near penetrators (see, e.g., [Army, 2013a] Tables 3-8 and 3-9). In the industrial worker, sportsman / recreationalist, and onsite resident farmer scenarios, the Army modeled the thickness of the contaminated zone with a uniform distribution from 1.0 to 3.3 feet (0.30 to 1.0 m). The Army characterized that range as conservative (see Section 3.4.2 of Appendix C of the DP) because using a fixed total contaminant mass with a thinner contaminated zone results in greater modeled surface soil concentrations. The NRC staff agrees with that characterization because the model was relied on principally to model groundwater-independent pathways, and the dose from those pathways tend to increase with

increasing contaminant concentrations near the surface. For example, the dominant pathways for the onsite scenarios were direct exposure and ingestion of contaminated plants and the projected doses from those pathways increase with increasing concentrations of radionuclides near the soil surface (for direct exposure) and in the root zone (for plant ingestion)[7]. Minimizing the modeled contaminated zone thickness could be non-conservative if using a smaller contaminated zone depth unrealistically increased the projected time that it would take for contamination to reach groundwater. However, because the Army chose to monitor groundwater concentrations, the Army does not need to rely solely on groundwater modeling results to demonstrate compliance with the public dose limits. Therefore, the NRC staff finds that the range used for the contaminated zone is appropriate because using a smaller modeled contaminated zone thickness increases the projected dose from groundwater-independent pathways such as external radiation and plant ingestion.

The Army assumed the source term for the souvenir hunter would be one penetrator. The NRC staff finds that assumption to be reasonable because of the low probability of finding a penetrator. The Army conservatively assumed the penetrator would be 2.64 kg (5.82 pounds), which is the largest intact fragment the Army expects to be present in the DU Impact Area (Army, 2013b). As explained in Section 3.4 of Appendix C of the Army's 2013 ER, that estimated maximum fragment size is based on the maximum observed fragment size during an Army study (Army, 1984) of the deflection of penetrators fired at earthen targets (i.e., turf) from different angles. The NRC staff finds the Army's use of the largest observed fragment from that study to be acceptable because assuming a larger penetrator volume and surface area increases the projected doses from external radiation and incidental ingestion while handling the penetrator.

3.2.2.3 Chemical Form

In the onsite scenarios, (i.e., Industrial Worker, Sportsman / Recreationalist, Onsite Resident Farmer) the Army assumed that DU will become available to the environment as it oxidizes from a metallic (i.e., zero-valent) form to a corroded (i.e., tetravalent) form. In the corresponding RESRAD-Offsite dose models, the Army makes the simplification that all of the DU is corroded and adsorbed to soil. The NRC staff finds that source term assumption to be appropriate because it increases the modeled available source term in the soil.

In the RESRAD-Offsite dose models, the Army uses the inhalation DCF corresponding to the slowest lung clearance class and the ingestion DCF corresponding to the higher of the two fractional absorption in the gastrointestinal tract (f_1) values in Federal Guidance Report 11 (EPA, 1988). The NRC staff finds this approach to be acceptable because using the slowest clearance class for the inhalation DCF and the ingestion DCF based on the higher f_1 value lead to higher projected doses than assuming a different clearance class or f_1 value.

In the souvenir hunter scenario, the inhalation doses were all calculated with RESRAD-Build (Version 3.5). In RESRAD-Build (Version 3.5), the slowest clearance class is used to calculate inhalation doses and that the parameter is not adjustable (Yu et al., 2007b). The NRC staff finds use of the slowest clearance class acceptable because it is a conservative assumption. The Army used an ingestion DCF corresponding to the lower of the two f_1 values for uranium in Federal Guidance Report 11 (i.e., 0.002 as compared to 0.05). The justification for using the lower f_1 value was it is the value recommended by ICRP 119 (ICRP, 2012) for uranium in a

[7] See Section 3.2.10 of this SER for further discussion of the Army's sensitivity analysis result for contaminated zone depth.

tetravalent chemical form, and the Army expects the uranium corrosion products to be in a tetravalent chemical form. The NRC staff finds the approach to be acceptable because the assumption that the uranium is tetravalent is consistent with the expected chemical form of the corrosion products.

3.2.3 Scenarios and Pathways

3.2.3.1 Scenarios

In the license amendment request, the Army reported dose projections for four scenarios: an onsite industrial worker, an onsite sportsman/recreationalist, a hypothetical onsite farmer, and a hypothetical individual who removes a penetrator from the site (called a "souvenir hunter"). The NRC staff finds that these scenarios represent an acceptable range of potential site uses that are consistent with the current and proposed land use. Specifically, an onsite industrial worker scenario is consistent with the current and proposed use of the site by FWS and INANG employees. The sportsman/recreationalist scenario is consistent with the current and proposed practice of allowing visitors to the Big Oaks National Wildlife Refuge. A resident farmer scenario is consistent with the agricultural use of land neighboring the JPG site. Although agricultural use of the DU area would not be permitted under a possession-only license, the dose to a hypothetical onsite resident farmer bounds the potential dose to an offsite resident farmer because of the much larger source term available in the soil and the greater potential for groundwater contamination. Therefore, the NRC staff finds that a demonstration that the public dose limit would be met for a hypothetical onsite resident farmer is an acceptable demonstration that the public dose limit would be met for a member of the public at the JPG boundary[8].

The NRC staff found consideration of a souvenir hunter scenario to be appropriate because it is reasonably foreseeable that a visitor to the site could find a DU penetrator and take it home. Although visitors would not be permitted to enter the DU Impact Area under a possession-only license, they would continue to be permitted in areas near the DU Impact Area (e.g., see "Special Hunting" Areas 48, 52, and 54 in Figure 3-2 of this SER) and no physical barrier prevents visitors in those areas from inadvertently entering the DU Impact Area (RSP, Sections 15.1 and 15.3 [Army, 2018]). In the DU Impact Area, penetrators can be found on the soil surface (e.g., see SAIC, 2008 Figure 1-5). The Army expects it to take at least 100 years for a DU penetrator to corrode completely (Army 2013a, Section 3.4.2). In addition, penetrators or significant fragments have been detected in Big Creek and North Tributary (Army 2013a, Section 3.6.2). The Army concluded that the movement of fragments offsite in surface water is unlikely because of the high density of the fragments except under unusual conditions such as flash floods (Army 2013b, Appendix E). Therefore, the souvenir hunter scenario is also applicable to the unlikely case that a penetrator is washed offsite and taken home by an individual.

[8] In the DP (Army, 2013a), the Army used RESRAD-Offsite (Version 2.6) to perform a detailed dose analysis for an offsite resident farmer scenario. However, that scenario was not referenced in the license amendment request.

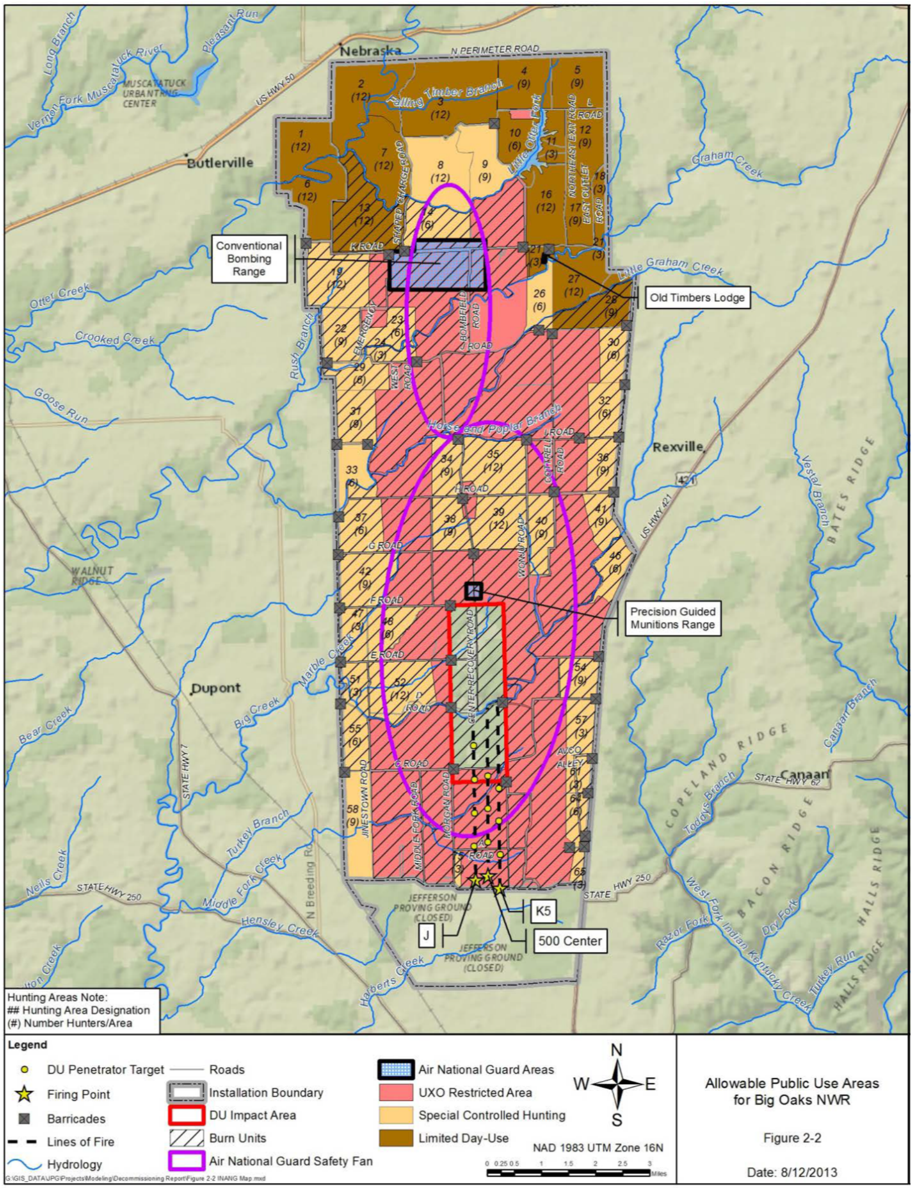

Figure 3-2. Land uses for the former JPG site (Reproduced from [Army, 2013a] Figure 2-2)

3.2.3.2 Pathway Selection

The NRC staff evaluated the exposure pathways considered for each of the four scenarios described in Section 3.2.3.1 of this SER and found the pathways to be acceptable.

For the onsite industrial worker, the Army considered three exposure pathways:

- external exposure to DU in soil in the PCZ and SCZ,
- inhalation of DU-containing dust, and
- incidental soil ingestion.

The NRC staff found those exposure pathways to be acceptable but questioned the exclusion of groundwater consumption from this scenario (NRC, 2015). The Army did not answer that RAI because the DP was withdrawn. However, the Army's proposal to monitor groundwater (Army,

2018) eliminates the need to include groundwater consumption in the dose projection for an industrial worker because the potential contribution from groundwater pathways can be bounded (See Sections 3.2.1 and 3.2.8 of this SER). Therefore, the NRC staff found the exposure pathways considered for the industrial worker scenario to be acceptable because the combination of the modeled pathways and the results from groundwater monitoring will adequately represent an industrial land use.

For an onsite sportsman or recreationalist scenario, the RESRAD-Offsite (Version 2.6) model that the Army submitted with the DP included the following exposure pathways:

- external exposure to DU in soil in the PCZ and SCZ;
- Inhalation of DU-containing dust;
- Ingestion of
    - game animals;
    - fish;
    - DU-containing soil; and
    - water from surface water body (incidental ingestion only)

The NRC staff found inclusion of these pathways to be acceptable because they are consistent with the current land use on the site and the expected behavior of a sportsman/recreationalist on the site, including hunters.

For the onsite resident farmer, the Army considered the following exposure pathways:

- external exposure to DU in soil in the PCZ and SCZ;
- Inhalation of DU-containing dust;
- Ingestion of
    - crops, meat, and milk from livestock raised on DU contaminated soil;
    - fish from stream or pond contaminated by DU leaching through soil;
    - incidental ingestion of DU-contaminated soil;
    - drinking water from groundwater that contains DU; and
    - crops, meat, and milk that depend on contaminated irrigation water.

The NRC staff finds these pathways to be acceptable because they are consistent with an agricultural scenario and the physical properties of the site. As described in Section 3.2.3.1 of this SER, an onsite residential farming scenario is not possible under a possession-only license. However, the results of this scenario would bound the dose to an offsite residential farmer.

For the souvenir hunter scenario, the Army evaluated exposure in four phases of activity: (1) two hours of direct contact while carrying a penetrator offsite, (2) two hours per year of sanding or grinding, (3) eight hours per year of other “aggressive handling” other than sanding or grinding, and (4) 730 hours per year of “incidental exposure” to the penetrator at 1 m (3.3 feet) distance and to contaminated dust on the workshop floor. For each phase of exposure, the Army considered external dose, inhalation, and incidental ingestion pathways. The NRC staff finds these pathways to be acceptable because they are consistent with the potential behavior of an individual who removes a penetrator from the site.

3.2.4 Mathematical Models Used in the Analysis

The Army used a combination of dose models and hand calculations to model the scenarios discussed in the license amendment request. The Army used RESRAD-Offsite (Version 2.6)

(Yu et al., 2007a) to model projected doses to an onsite industrial worker, a sportsman / recreationalist, and a hypothetical resident farmer. RESRAD-Offsite is computer code that models projected doses to individuals both on and near a radioactively contaminated site. The Army used a combination of the computer code RESRAD-Build (Version 3.5) (Yu et al., 2007b) and hand calculations to project the dose to the hypothetical souvenir hunter. RESRAD-Build is a computer code that models projected doses to individuals in radioactively contaminated buildings.

RESRAD-Offsite (Version 2.6) requires some simplifications of the known site conditions. The NRC staff identified the following main simplifications: (1) simplifications in groundwater modeling, (2) the assumption that the source term can be modeled with two concentration zones (i.e., the SCZ and PCZ) and that the concentration in each does not change with depth in a 15-cm (6 inch) deep contaminated zone, and (3) the assumption that the source term is adsorbed to the soil.

Regarding the first assumption, the NRC staff determined that the simplifications in the modeled groundwater transport are acceptable because the Army chose to rely on groundwater monitoring, rather than groundwater modeling, as part of its demonstration of compliance with the 10 CFR Part 20 Subpart C public dose limits and 10 CFR Appendix B effluent limits. Therefore, the NRC staff did not rely on the groundwater model submitted with the DP in its review of the license amendment.

Regarding the second assumption, RESRAD-Offsite (Version 2.6) requires that each run contain only a single source term with a uniform concentration. The Army worked around this limitation by using multiple model runs for each scenario. For the onsite industrial worker, the sportsman/recreationalist, and the hypothetical onsite resident farmer, the Army used three models runs for the dose assessment: one representing the dose from the PCZ, and two model runs representing the contributions from left and right SCZs, respectively. The Army then added the projected doses from each of the model runs. The NRC staff found this approach to be acceptable because the effects of the contamination from the PCZ and SCZ would be additive.

Regarding the third assumption, RESRAD-Offsite (Version 2.6) also required the simplification that the source term be represented as entirely available for transport and adsorbed to the soil. That is, RESRAD-Offsite (Version 2.6) could not represent the corrosion and dissolution of the DU penetrators. Instead, the model represented the penetrators as if they were entirely corroded and adsorbed to soil at the beginning of the model run. The Army indicated that this was a conservative simplification because the uranium is expected to become available for transport more slowly as the penetrators corrode and the uranium dissolves. RESRAD-Offsite (Version 3.1) can represent the more gradual corrosion and dissolution of the penetrators. However, the NRC staff agrees that the assumption that the uranium is all available for plant uptake at the beginning of the model run is conservative. Therefore, the NRC staff found the choice of RESRAD-Offsite (Version 2.6) to be acceptable.

For the onsite industrial worker, sportsman / recreationalist, and hypothetical resident farmer scenarios, the Army used RESRAD-Offsite probabilistically[9]. The Army's choice of parameters

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[9] A probabilistic model is a model in which certain input parameters are represented by a distribution of values instead of single numerical values. The model is run many times and different values of the probabilistic parameters are randomly selected each time. Each model run is called a "realization." The set of realizations yields a distribution of possible dose projections. As discussed in Appendix I of

to model with uncertainty distributions is reviewed in Section 3.2.10 of this SER. For each model, the Army compared the results of three sets of realizations started with a different random seed to demonstrate that each set contained a sufficient number of realizations. The NRC staff found that the Army had used a sufficient number of realizations because the peak of the mean results for the three sets of realizations for each model run were essentially identical. The Army used the peak of the mean of the realizations for each model run (i.e., three sets of 100 realizations each for the onsite resident farmer and three sets of 37 model realizations each for the industrial worker and sportsman / recreationalist) to compare to the dose criteria. The NRC staff found that approach to be acceptable.

For the souvenir hunter scenario, the Army used a combination of hand calculations and model runs with RESRAD-Build (Version 3.5) to develop a dose projection. The Army used hand calculations to project the external radiation dose and inadvertent ingestion of corrosion products while the individual directly handled the penetrator. The Army used four RESRAD-Build model runs to represent the remaining exposure pathways during the four phases of exposure (see Table 3-3 of this SER). The Army then added the doses from hand calculations and four model runs. The NRC staff found that approach to be acceptable because the doses are additive, and the combination of model runs, and hand calculations included all of the expected exposure pathways.

For the souvenir hunter scenario, the Army ran RESRAD-Build deterministically with conservative parameter choices. As discussed in Appendix I of NUREG-1757, Volume 2, deterministic model runs can be appropriate for calculations with relatively simple conceptual models because, for a simpler conceptual model, it is easier to ensure that specific parameter values are conservative in the context of the overall dose calculation (i.e., will not underestimate dose results). In contrast, with a more complex conceptual model, it can be difficult to determine whether specific parameter choices will lead to conservative or non-conservative overall dose results. Because the souvenir hunter scenario had a relatively simple conceptual model, the NRC staff found the use of a deterministic model with conservative parameter choices to be an acceptable approach. Parameter values for this scenario are reviewed in Section 3.2.9 of this SER.

3.2.5 Parameter Value Selection

The NRC staff reviewed the Army's process for selecting parameter values and the justification for the parameter values used.

For the onsite industrial worker, sportsman/recreationalist, and hypothetical onsite resident farmer scenarios, the Army indicated that it used the following order of preference for selecting parameter values (Army, 2013a):

- Empirical site-specific data
- Literature values based on site-specific conditions (e.g., density and porosity for a site-specific soil type)
- Calculated values from data presented in NUREG/CR-6697 and NUREG/CR-6937
- Most likely or expected values from NUREG/CR-6697 and NUREG/CR-6937
- Professional judgment (e.g., sportsman's onsite occupancy)

NUREG-1757, Vol. 2, compliance is then often determined by comparison of the peak of the mean projected dose with the regulatory dose criterion; however, other probabilistic measures also can be used in some circumstances.

The NRC staff finds that approach to be acceptable because it is designed to maximize the use of available site-specific data and because the conceptual model for the JPG site is consistent with the conceptual model underlying the data in NUREG/CR-6697 and NUREG/CR-6937. The NRC staff found the parameter values used in the onsite industrial worker, sportsman/recreationalist, and hypothetical resident farmer scenarios to be acceptable because they were based on a combination of available site-specific data, appropriate literature sources, and conservative assumptions.

In the souvenir hunter scenario, the Army used a combination of site-specific data (e.g., the size of a large penetrator fragment), data from literature sources, and conservative assumptions about the receptor behavior. The NRC staff evaluated the bases of the parameters used and found them to be acceptable because they were based on available site-specific data, appropriate literature sources, and conservative assumptions.

3.2.6 Onsite Industrial Worker

In the license amendment request, the Army referenced a dose analysis for an onsite industrial worker that was originally documented in the DP (Army, 2013a) and compared that projected dose (i.e., 0.059 mSv/yr [5.9 mrem/yr]) to the 10 CFR 20.1301 dose limit for individual members of the public (i.e., 1 mSv/yr [100 mrem/yr]) rather than the 10 CFR Subpart C occupational dose limits (10 CFR 20.1201). As mentioned in Section 3.0, the Army did not include a separate dose projection to demonstrate that occupational exposures would be within regulatory limits. However, even though the Army's analysis considers the industrial worker scenario in the context of the public dose limits, the NRC staff determined that the modeled exposure time in the DU Impact Area also made the results for the industrial worker scenario relevant to occupational exposures. Therefore, in this section, the NRC staff uses the projected dose to an onsite industrial worker to evaluate compliance with both public and occupational dose limits.

The Army's analysis of dose to an onsite industrial worker was based on the projected exposure of an FWS or INANG worker who spends an entire work-year (i.e., 2000 hours) in the PCZ. The Army characterized this assumption as "highly implausible" in the DP. The NRC staff agrees that an industrial worker is unlikely to spend 2,000 hours annually (which is the total number of work hours in a year) in the PCZ because the PCZ is a small fraction of the site, the onsite workers do not have a reason to spend more time in the PCZ than the rest of the site, and the UXO in the DU area would discourage FWS and INANG workers from spending any unnecessary time in the PCZ. The NRC staff finds it acceptable and conservative for the Army to assume an industrial worker spends 2000 hours a year in the PCZ because they are likely to spend most of their time in uncontaminated areas, resulting in a lower dose than projected by assuming they spend all of their working hours in the PCZ.

For the onsite industrial worker, the Army considered external exposure to DU in soil in the PCZ and SCZ, inhalation of DU-containing dust, and incidental soil ingestion. The Army projected a dose of 0.059 mSv/yr (5.9 mrem/yr) from the sum of external radiation, inhalation, and incidental soil ingestion. Most of that projected dose (i.e., 0.054 mSv/yr [5.4 mrem/yr]) was due to external radiation. The NRC staff reviewed the parameters the Army used in the RESRAD-Offsite (Version 2.6) model to project that dose and found them to be acceptable.

The Army did not consider potential groundwater consumption for an industrial worker. However, because the Army has proposed to monitor groundwater concentrations of uranium isotopes, the contribution from groundwater consumption can be bounded by the projected dose from drinking water at the 10 CFR Part 20 Appendix B limits. Those limits were established

based on a projected dose of 0.50 mSv/yr (50 mrem/yr) for an individual who consumes all of his annual water from the contaminated source. To adjust that value for the potential exposure for an industrial worker, the NRC staff multiplied that value by 0.5, based on the assumption that approximately 1/2 of the industrial worker's annual water intake would come from the contaminated source at work (i.e., 0.25 mSv/yr [25 mrem/yr]). Other groundwater-based pathways, such as ingestion of plants contaminated by irrigation with contaminated groundwater, are not applicable to the industrial worker scenario.

Combined with the TEDE from hypothetical groundwater ingestion at the 10 CFR Part 20 Appendix B effluent limits, the Army's projected dose of 0.059 mSv/yr (5.9 mrem/yr) TEDE from groundwater-independent pathways meets the 10 CFR 20.1301 limit of 1.0 mSv/yr (100 mrem/yr) TEDE for the individual member of the public likely to receive the highest dose. In addition, the projected dose to an industrial worker meets the 10 CFR 20.1201(a)(1)(1) occupational dose limit of 0.05 Sv/yr (5 rem/yr) TEDE. The projected dose to an industrial worker also meets the 10 CFR 20.1207 5 mSv/yr (500 mrem/yr) TEDE occupational dose limit for a minor. The projected dose to an industrial worker is also less than 10 percent of the 10 CFR 20.1208 limit of 5 mSv/yr (500 mrem/yr) TEDE to a declared pregnant woman.

The NRC staff expects the source of external exposure for industrial workers at the JPG to be DU corrosion products mixed with soil in the DU Impact Area and infrequent exposure to penetrators on or near the ground surface. External dose from DU in the soil contributed 0.054 mSv/yr (5.4 mrem/yr) of the 0.059 mSv/yr (5.9 mrem/yr) TEDE the Army projected an onsite industrial worker would receive. That dose indicates it is highly unlikely that any occupational dose would exceed either (1) the 10 CFR 20.1201(a)(1)(ii) limit of 0.5 Sv (50 rems) on the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye or (2) the 10 CFR 20.1201(a)(2)(i) limit of a lens dose equivalent of 0.15 Sv (15 rem). It is also highly unlikely that a minor would receive an occupational dose exceeding the limit of 10 percent of those values required by 10 CFR 20.1207.

The skin dose from direct contact with metallic DU is estimated by the IAEA (IAEA, 2009) to be 2.5 mSv/yr (250 mrem/hr). In the infrequent case in which an industrial worker handles a penetrator, it is highly unlikely that an adult industrial worker would have direct contact with a DU penetrator for the 200 hours required to exceed the 10 CFR 20.1201(a)(2)(ii) limit of 0.50 Sv (50 rem) (i.e., 2.5 mSv/hr x 200 hours = 0.50 Sv) to the skin. In addition, it is also unlikely that a minor would have the 20 hours of direct contact with a DU penetrator required to receive a dose of 0.05 Sv (5 rem) (i.e., 2.5 mSv/hr x 20 hours = 0.05 Sv) to the skin. Similarly, it is unlikely that an industrial worker would have enough direct contact with a DU penetrator to exceed the 10 CFR 20.1201(a)(2)(ii) shallow-dose limit of 0.50 Sv (50 rem) to the whole body or any extremity, or for a minor to receive 10 percent of those values.

The use of individual monitoring devices for external dose is required, pursuant to 10 CFR 20.1502(a), for:

- adults who are likely to receive an annual dose from sources external to the body in excess of any of the following (each evaluated separately)

  — 5 mSv [500 mrem] deep-dose equivalent
  — 15 mSv [1.5 rem] lens (of the eye) dose equivalent
  — 50 mSv [5 rem] shallow-dose equivalent to the skin
  — 50 mSv [5 rem] shallow-dose equivalent to any extremity

- minors who are likely to receive an annual dose from sources external to the body in excess of any of the following (each evaluated separately)

  — 1.0 mSv [100 mrem] deep-dose equivalent
  — 1.5 mSv [150 mrem] lens (of the eye) dose equivalent
  — 5 mSv [500 mrem] shallow-dose equivalent to the skin
  — 5 mSv [500 mrem] shallow-dose equivalent to any extremity

- declared pregnant women who are likely to receive a dose from radiation sources external to the body during the entire pregnancy in excess of 1.0 mSv [100 mrem] deep-dose equivalent

- individuals entering a high or very high radiation area

The NRC staff compared the projected external dose to an onsite industrial worker to these regulatory limits and found that it is highly unlikely that an onsite industrial worker would exceed these exposures. Based on the dose analysis described in this section, the NRC staff also concluded that it is highly unlikely the external dose to a minor or declared pregnant woman would exceed the dose criteria listed above. In addition, there are no high or very high radiation areas on site. Therefore, the NRC staff determined that there are no conditions that indicate the need for external exposure monitoring to demonstrate compliance with the occupational dose limits of 10 CFR Part 20 Subpart C.

Internal exposure monitoring is required, pursuant to 10 CFR 20.1502(b), for the following individuals:

- adults likely to receive in, 1 year, an intake exceeding 10 percent of the applicable annual limit on intake (ALI) for ingestion and inhalation
- minors likely to receive, in 1 year, a committed effective dose equivalent exceeding 1.0 mSv [100 mrem] and declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent exceeding 1 mSv [100 mrem]

The NRC staff compared the projected intakes from inadvertent soil ingestion and inhalation to the 10 CFR Part 20 Appendix B ALI for ingestion and inhalation and found that it is highly unlikely that an individual would exceed 10 percent of those values. In addition, based on the dose analysis described in this section, the NRC staff concluded that it is highly unlikely the CEDE to a minor or declared pregnant woman would exceed the dose criteria listed above. Therefore, the NRC staff determined that there are no conditions that indicate the need for internal exposure monitoring to demonstrate compliance with the occupational dose limits of 10 CFR Part 20 Subpart C.

3.2.7 Onsite Sportsman/Recreationalist

To evaluate the potential exposure to a sportsman or recreationalist on the JPG site, the Army evaluated the radiological exposure to an individual accessing the site for all 103 days per year that visitors are permitted on the Big Oaks National Wildlife Refuge. The Army also conservatively assumed the individual would spend all of this time in the PCZ, although visitors would be prohibited from entering the DU Impact Area under a possession-only license. The NRC staff found these occupancy assumptions to be acceptable because they are the maximum occupancy time the Army would allow.

The Army considered external exposure to DU in soil in the PCZ and SCZ, inhalation of DU-containing dust, and ingestion of game animals, fish, DU-containing soil and water from

surface water body (incidental ingestion only). As discussed in Section 3.2.3 of this SER, the NRC staff found those pathways to be acceptable because they were consistent with the site characteristics and the exposure scenario. The greatest contribution to the projected dose for the sportsman or recreationalist was external exposure (84 percent of the projected dose) followed by incidental soil ingestion (seven percent of the projected dose). The projected dose from those pathways is bound by the projected dose to a hypothetical resident farmer because the exposure time is greater for the onsite resident farmer and the pathways are otherwise modeled the same way in both scenarios. In addition, the projected dose from inhalation of DU-containing dust is greater for the onsite resident farmer because a greater air mass loading is assumed during gardening and the total exposure time is greater. Therefore, compliance with the 10 CFR Part 20 Subpart D public dose limits and the 10 CFR 20.1101(d) ALARA constraint on dose from the air pathway are discussed in detail in terms of the onsite resident farmer scenario in Section 3.2.8 of this SER.

The two pathways evaluated for the onsite sportsman or recreationalist scenario that are not evaluated for the onsite resident farmer are game consumption and incidental surface water ingestion. The NRC staff evaluated the parameters associated with those pathways and found them acceptable because they were based on available site-specific data, appropriate literature values, and conservative assumptions. Neither pathway contributed significantly to the projected dose to the onsite sportsman/recreationalist.

Because RESRAD-Offsite (Version 2.6) does not model a separate “game consumption” pathway, the Army modeled game consumption by modeling game as beef cattle that consume contaminated soil, plants, and surface water from the PCZ. In addition, the Army provided model support for the game consumption pathway by referencing the results of deer tissue sampling from the JPG site and demonstrating that the projected dose from consuming deer meat at the measured concentrations in an amount equivalent to the expected amount of beef in the sportsman’s diet was less than 0.001 mSv/yr (1 mrem/yr). The NRC staff finds the use of previous deer tissue sampling results to be acceptable because the staff expects the exposure of game animals to DU to decrease with time as the DU is transported from the soil surface into deeper soil.

3.2.8 Onsite Resident Farmer Scenario

In the license amendment request, the Army referenced the projected dose to a hypothetical onsite resident farmer to demonstrate that the applicable public dose limits would be met. As discussed in Section 3.2.3.1, the NRC staff found it appropriate for the Army to evaluate an onsite resident farmer scenario. The NRC staff compared the dose projections from the onsite resident farmer scenario to the public dose limits in 10 CFR Part 20 Subpart D and the ALARA constraint on doses from the air pathway in 10 CFR 20.1101(d).

The Army assumed the farm was aligned with the PCZ so that the dwelling, leafy vegetable garden, and garden of fruits and other vegetables occur entirely in the PCZ (orange, pink, and blue squares on Figure 3-1), while larger areas of grain cultivation and pasture, which exceed the width of the PCZ, are 25 percent in the PCZ and 75 percent in the SCZ (light green and green squares on Figure 3-1). The NRC staff found this approach to be acceptable because other reasonably foreseeable arrangements of the dwelling and agricultural areas are unlikely to result in a higher projected dose. As discussed in Section 3.2.2 of this SER, the NRC staff found the source term concentrations of uranium in the PCZ and SCZ to be acceptable because they were consistent with site-specific information. The Army represented the resident’s time outside on the PCZ, inside the house in the PCZ, and outside in agricultural areas in the SCZ

with probabilistic distributions drawn from NUREG/CR-6697. The NRC staff found those values to be acceptable because they were taken from an acceptable literature source that was consistent with the scenario being modeled.

As discussed in further detail in Section 3.2.3.2 of this SER, the Army considered a range of agricultural exposure pathways, including external exposure to DU in the soil in the PCZ and SCZ, inhalation of contaminated dust, and consumption of contaminated crops, milk, meat, fish, soil, and groundwater. The NRC staff found those pathways to be acceptable because they are consistent with the conceptual model and site characteristics. The largest contributions to dose from the onsite resident farmer scenario were from external exposure (51 percent of the projected TEDE) and plant ingestion (39 percent of the projected TEDE). The NRC staff evaluated the parameters associated with those pathways and found them to be acceptable because they were based on a combination of site-specific information, acceptable literature sources, and conservative assumptions.

The projected doses from external exposure and plant ingestion were both sensitive to the concentration of uranium in the contaminated zone. That value, in turn, is sensitive to the areal extent of the contaminated zone, total mass of DU in the contaminated zone, the thickness of the contaminated zone. The NRC staff found the areal extent of the contaminated zone and the mass of DU in the contaminated zone to be acceptable because they were based on site-specific information. Furthermore, the NRC staff found the choice of splitting the contaminated zone into the more-contaminated PCZ and less-contaminated SCZ to be acceptable because it was consistent with site data and because it increased the projected dose compared to modeling the contaminated zone with one uniform concentration. As discussed in Section 3.2.2 of this SER, the NRC staff found the modeled thickness of the contaminated zone of 1.0 to 3.3 feet (0.30 to 1.0 m) to be acceptable because it was an underestimate of the measured thickness of the contaminated zone, which would increase the dose from the dominant exposure pathways (i.e., direct radiation and plant ingestion). Furthermore, any potential non-conservative effect of shortening the time required for radionuclides to reach groundwater is addressed by the Army's proposal to monitor uranium concentrations in groundwater.

The Army demonstrated the dose to an individual living and farming in the DU Impact Area is expected to meet the 10 CFR 20.1301(a)(1) 1 mSv/yr (100 mrem/yr) public dose limit with a combination of monitoring commitments and dose modeling. The dose contribution from drinking groundwater and surface water is limited by the Army's commitment to monitor surface and groundwater to comply with the 10 CFR Part 20 Appendix B effluent concentration limits for operating facilities. Those limits are based on a projected TEDE of 0.5 mSv/yr (50 mrem/yr) to an adult who obtains his entire annual intake of water from the contaminated source. The technical basis for the effluent limits did not include other water-based pathways, such as consumption of plants contaminated by irrigation with contaminated water. Therefore, to assess the potential dose contributions from groundwater-dependent pathways in the unexpected case that the groundwater concentrations reached the 10 CFR Part 20 Appendix B effluent concentration limits, the NRC staff conducted an independent analysis.

To conduct that analysis, the NRC staff modified the Army's RESRAD-Offsite (Version 2.6) input files for the hypothetical onsite farmer. The NRC staff removed the modeled unsaturated zones to mimic an elevated water table. The staff also adjusted the leach rate so that the peak projected total uranium concentration in groundwater was forced to be 11.1 Bq/L (300 pCi/L) with the same isotopic distribution as the penetrators. To achieve that hypothetical groundwater concentration, the NRC staff imposed a leach rate of 5×10^{-3} per year (annual fractional release). For comparison, the leach rate in the Army's onsite resident farmer model was

8 x 10^{-4} per year. That leach rate was derived from the contaminated zone sorption coefficients (i.e., "K_d" values) that the Army measured with laboratory measurements of site soil samples. The NRC staff evaluated the procedures for the soil sampling and laboratory studies the Army used to measure those sorption coefficients and found them to be reasonable and appropriate. Based on that assessment, the NRC staff finds that the sorption coefficients, and the leach rate derived from the sorption coefficients in the Army's analysis, are well-supported. Therefore, the hypothetical leach rate of 0.005 per year that was imposed for the sensitivity analysis is not the expected condition.

The results of that sensitivity analysis indicated that the peak of the mean dose increased to 0.72 mSv/yr (72 mrem/yr), primarily due to ingestion of contaminated drinking water (57 percent of peak dose) and ingestion of plants contaminated by irrigation with contaminated groundwater (25 percent of peak dose). The doses from external radiation and groundwater-independent plant uptake both decreased as compared to the Army's model of the onsite resident farmer scenario because the contaminated zone concentrations of uranium isotopes were reduced by the high hypothetical leach rate. The results of this sensitivity analysis are not the expected case. However, the results demonstrate that, in the unexpected case that the groundwater became contaminated at concentrations equal to the 10 CFR Part 20 Appendix B limits and site groundwater was used as a source of drinking water, irrigation water, and water for livestock, the projected dose would not exceed the 10 CFR 20.1301(a)(1) 1 mSv/yr (100 mrem/yr) TEDE public dose limit. The Army's action level for total uranium in surface or groundwater is established in the Army's Standard Operating Procedure for environmental monitoring (Army, 2000) to be one half the 10 CFR Part 20 Appendix B limits. That is, the Army's action levels are 5.55 Bq/L (150 pCi/L) for U-238, U-235, and U-234, applied as a sum of fractions. Therefore, the Army's action level being set at one half the effluent limit concentrations provides further assurance that the 10 CFR Part 20 Appendix B effluent limits and the public dose limits would be met.

The Army's dose projection for the onsite resident farmer scenario was 0.26 mSv/yr (26 mrem/yr). The NRC staff independently verified the groundwater-independent pathways in the models the Army used to develop that dose projection and found them to be accurate. In addition, as previously discussed, the NRC staff evaluated the potential dose from groundwater pathways in the unlikely case that the groundwater became contaminated at uranium concentrations equal to the 10 CFR Part 20 Appendix B effluent limits. In both cases, the NRC staff found that the projected dose was less than the 10 CFR 20.1301(a)(1) public dose limit of 1 mSv/yr (100 mrem/yr) TEDE.

The Army's RESRAD-Offsite analysis for the hypothetical resident farmer scenario also supported a finding of compliance with the 10 CFR 20.1301(a)(2) dose limits for external exposure. The projected peak dose from external exposure to an individual living and farming in the DU Impact Area was 0.12 mSv/yr (12 mrem/yr). That dose accounts for time outdoors in the PCZ as well as indoors in the PCZ and outdoors in the SCZ. Therefore, converting that projected dose to an hourly dose would understate the peak hourly dose, which would occur outdoors in the PCZ. Because the Army did not calculate the dose from external radiation outdoors in the PCZ separately from the annual dose, the NRC staff modified the Army's probabilistic RESRAD-Offsite model to determine the external dose rate outdoors on the PCZ. That dose rate was 2.4 x 10^{-5} mSv/hr (0.0024 mrem/hr). The 10 CFR 20.1301(a)(2) limits the dose in any unrestricted area from external sources to 0.02 mSv/hr (2 mrem/hr). Although the DU Impact Area is a controlled area, the limit is relevant because 10 CFR 20.1301(b) indicates that, if the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals (e.g., FWS or INANG workers).

The demonstration that the projected dose rate in the PCZ is expected to be less than 1 percent of the 0.02 mSv/hr (2 mrem/hr) limit demonstrates that 10 CFR 20.1301(a)(2) will be met.

The Army also used RESRAD-Offsite model runs to demonstrate that the dose from airborne effluents from the DU Impact Area is expected to meet the 10 CFR 20.1101(d) 0.10 mSv/yr (10 mrem/yr) limit on the projected dose from air emissions (excluding Radon-222 and its progeny). The Army RESRAD-Offsite model runs indicated that the inhalation dose to an individual living and farming onsite, which would bound the dose from air effluents from the site, was projected to be 0.0021 mSv/yr (0.21 mrem/yr), in compliance with the 10 CFR 20.1101(d) 0.10 mSv/yr (10 mrem/yr) limit.

To test the uncertainty in that result, the NRC staff ran an additional probabilistic model run using uncertainty distributions for the inhalation rate, mass loading for inhalation, mean onsite mass loading, and indoor to outdoor dust concentration using the default uncertainty distributions in RESRAD-Offsite (Version 2.6). That analysis showed a slight decrease in the peak of the mean annual dose from inhalation compared to the Army's analysis (i.e., from 0.0021 mSv to 0.0020 mSv). That analysis demonstrated that uncertainty in parameters related to the inhalation dose are not likely to change the demonstration of compliance with the 10 CFR 20.1101(d) 0.10 mSv/yr (10 mrem/yr) limit.

In addition to the regulatory limit, NRC guidance document NUREG-1556 Vol. 7 indicates that unmonitored effluents should not exceed 30 percent of the total estimated effluent releases or 10 percent of the permissible air effluent concentrations found on column 1 of Table 2 in 10 CFR Part 20, Appendix B, whichever is greater. Deterministic RESRAD-Offsite model runs for an individual living and farming in the DU Impact Area projected a peak air concentration above the PCZ to be 2.5×10^{-5} pCi/m^3 U-234, 1.7×10^{-6} pCi/m^3 U-235, and 1.4×10^{-4} pCi/m^3 U-238, which are each less than 1 percent of the 10 CFR Part 20 Appendix B air effluent limits for the most restrictive chemical forms of uranium for each isotope. The NRC staff expects that the air concentration above the PCZ would bound the air concentration at the JPG boundary because of the added time and distance for dispersion of radionuclides in air between the DU Impact Area and the JPG boundary. Therefore, the projected dose supports the NRC decision not to require monitoring of air effluents from the DU Impact Area.

3.2.9 Souvenir Hunter Scenario

To support the license amendment request, the Army evaluated the projected dose to an individual who finds a DU penetrator onsite and takes the penetrator home as a souvenir. This scenario is referred to as the "souvenir hunter" scenario. The Army used a combination of hand calculations and the software program RESRAD-Build (Version 3.5) to evaluate the projected dose to a souvenir hunter.

The Army assumed the source term for the souvenir hunter would be one penetrator fragment weighing 2.64 kg (5.82 pounds). As discussed in Section 3.2.2.2 of this SER, the NRC staff found that assumption to be acceptable. For the RESRAD-Build model runs, the Army assumed the souvenir hunter was in a workshop that was 4 m wide by 4 m long (13 ft by 13 ft) with 2.5 m (8.2 ft) high ceilings, to approximate the size of a small shop/garage (Army, 2016). The NRC staff finds this assumption to be acceptable because it is a reasonable approximation of a workshop size.

As discussed in Section 3.2.4 of this SER, the Army used a combination of four separate RESRAD-Build model runs and hand calculations to project the dose in the souvenir hunter

scenario. The NRC staff found that approach acceptable because the results were additive, and the combination of model runs, and hand calculations included all of the expected exposure pathways. The total projected dose to the souvenir hunter was 0.67 mSv/yr (67 mrem/yr) (Army, 2018). The projected dose from each exposure route for each phase of exposure is given in Table 3-3 of this SER.

In the souvenir hunter scenario, the main pathway contributions were from the contribution to the TEDE from the dose to the skin during direct contact, and the inhalation dose from inhaling contaminated dust from the workshop floor during the 730 hours of incidental exposure. The dose to the skin was calculated with a hand calculation based on a dose rate for handling metallic DU (IAEA, 2009). The NRC staff found that parameter to be acceptable because it matched the exposure scenario.

For the inhalation dose during the incidental exposure period, the air exchange rate and breathing rate were taken from the mean or most expected values from the distributions given in NUREG/CR-6697. For the incidental exposure period, the Air Release Fraction (ARF) was based on the NUREG/CR-6697 value for metal oxidation and the DOE Handbook (DOE, 2013) bounding value for a spill and impact of a contaminated surface. The NRC staff found those values to be acceptable for the incidental exposure period because they were based on appropriate literature values and were consistent with the conceptual model.

For the mechanical abrasion period (i.e., sanding or grinding), the NRC staff conducted an independent analysis that demonstrated that the projected dose was sensitive to the ARF. In a revised analysis (Army, 2018), the Army used an ARF of 0.07 to model the two hours of mechanical abrasion. That value was based on the DOE handbook (DOE, 2013) value for explosive stress on a contaminated solid. The NRC staff finds that value acceptable because it is based on appropriate literature values and is consistent with the conceptual model.

The NRC staff reviewed the bases for the other parameters used and found them to be acceptable because they were based on a combination of appropriate literature sources and conservative assumptions.

Table 3-3. Exposure routes and projected doses to an individual who removes a penetrator from JPG

Exposure Phase [a]	Duration (hours)	TEDE (mrem) (Sum of Columns to Right) [b]	Components of TEDE		
			External (mrem) [b]	Ingestion (mrem) [b]	Inhalation (mrem) [b]
Carrying penetrator offsite	2	5	5	Not calculated [c]	Not calculated
Mechanical abrasion	2	16.22	5 (handling penetrator) 0.0023 (dust on floor)	6.73 [c] (handling penetrator) 0.0071 (resuspended dust from floor)	4.48 (dust generated from sanding)
Aggressive handling other than mechanical abrasion	8	22.51	20 (handling penetrator) 0.012 (dust on floor)	2.21 [c] (handling penetrator) 0.00045 (resuspended dust from floor)	0.29 (re-suspended dust from floor)
Time in workshop not handling penetrator	730	23.61	1.9 (penetrator on shelf) 1.1 (dust on floor)	0.21 (resuspended dust from floor)	20.4 (re-suspended dust from floor)
Total		**67.3**	**33**	**9.1**	**25.2**

[a] Exposure phases are described in Section 3.2.3.2 in this SER
[b] To convert mrem to mSv, divide by 100.
[c] The Army's calculation of the dose from incidental ingestion during handling accounted for loss of lose corrosion products from the penetrator surface due to the handling. Therefore, the calculated dose per hour decreased as the penetrator was handled. For this reason, the incidental ingestion dose during the two hours of mechanical abrasion is greater than the incidental ingestion dose during the subsequent eight hours of aggressive handling. In addition, adding two hours to the calculation (e.g., by assuming the first two hours of handling occurred while the penetrator was carried off site) would have changed the timing of the incidental ingestion dose but would have hand an insignificant effect on the total dose.

3.2.10 Sensitivity and Uncertainty Analyses

The Army supported its dose projections with sensitivity and uncertainty analyses designed to identify parameters that had a significant effect on dose and evaluate the potential effects of uncertainty in those parameters on dose projections.

To determine which parameters to include in the sensitivity analysis, the Army considered the prioritization of RESRAD parameters given in NUREG/CR-6697 Attachment A, Table 4.2. The Army included seven of the ten top-priority parameters listed in that NUREG in its sensitivity analysis: distribution coefficient, density of contaminated zone, density of saturated zone, saturated zone total porosity, saturated zone effective porosity, saturated zone hydraulic

conductivity, and unsaturated zone thickness. In addition to these seven Priority 1 parameters the Army included in the sensitivity analysis, the Army included the thickness of the contaminated zone, which was classified as a second-priority parameter in NUREG/CR-6697.

The three top priority parameters identified in NUREG/CR-6697 that the Army did not include in its sensitivity analysis were the density of cover material, depth of roots, and transfer factors for plants. The NRC staff found it was acceptable not to include the density of the cover material because the site will not have cover material. The Army indicated that the depth of roots and transfer factors for plants were not included because there was no site-specific reason to select certain plants a hypothetical farmer or gardener would grow. The NRC staff found the selection of parameters was acceptable except that the uncertainty in root depth and plant factors should be assessed because ingestion of contaminated plants was the largest contributor to projected dose in the onsite resident farmer scenario. To address this issue, the NRC staff conducted an independent analysis by adding uncertainty distributions for the root depth and soil to plant transfer factors. The staff used the generic distributions in NUREG/CR-6697. The NRC staff determined that adding these uncertainty distributions increased the projected peak of the mean dose by eighteen percent. That increase did not change the demonstration of compliance with the 10 CFR Part 20 Subpart D public dose limits. Because the increase was due to plant ingestion, which is not applicable to the industrial worker scenario, the increase also did not affect the demonstration of compliance with the 10 CFR Part 20, Subpart F requirements for individual monitoring of external and internal occupational dose.

The sensitivity analysis results in Appendix B of the DP show that in the RESRAD-Offsite sensitivity analysis, dose increased, rather than decreased, with increasing thickness of the contaminated zone. That result is counterintuitive for the hypothetical onsite resident farmer scenario because the main dose pathways were external exposure from DU in the soil and ingestion of plants contaminated by uptake of DU from the soil. Exposure from both of those pathways would increase if the DU inventory was modeled in a shallower contaminated zone because the modeled concentration would increase. As explained in the DP, the counterintuitive sensitivity analysis result occurred because the Army did not inversely correlate the contaminated zone thickness and radionuclide concentrations, which caused an unrealistic increase in the source term as the contaminated zone depth increased.

The Army conducted an additional sensitivity analysis focused on contaminated zone thickness by comparing the deterministic results for the onsite resident farmer scenario run with contaminated zone thicknesses of 0.3 m (1 foot) and 1 m (3.3 feet). The Army adjusted the contaminated zone radionuclide concentrations so that the total amount of DU in the contaminated zones was equivalent in both cases. The NRC staff found that this was an appropriate approach for the JPG site because the total inventory is more certain than the contaminant concentrations. The Army found that assuming a thinner, but more concentrated, contaminated zone increased the deterministic dose estimate by approximately 30 percent, but that both dose estimates were less than the peak of the mean value from the probabilistic analysis that the Army used to demonstrate compliance. Although there is some evidence the contaminated zone could be thicker than the range tested (i.e., greater than 1 m [3.3 feet]), as discussed in Section 3.2.2 of this SER, the NRC staff found that assuming a shallower contaminated zone was conservative for the groundwater-independent pathways and that the groundwater pathways would be addressed by monitoring. Therefore, the NRC staff found that the Army's sensitivity analysis was acceptable to assess the potential effects of uncertainty in the modeled contaminated zone depth and that that uncertainty would not change the compliance demonstration.

The Army also conducted a probabilistic uncertainty analysis for the industrial worker, the sportsman/recreationalist, and the hypothetical onsite resident farmer. For the uncertainty analyses, the Army included the following parameters:

- Contaminated zone thickness
- Contaminant concentrations
- Contaminated zone hydraulic conductivity
- Distribution coefficients for each contaminant in the contaminated zone
- Distribution coefficients for each contaminant in both of two unsaturated zones
- Upper unsaturated zone thickness (based on total fixed UZ thickness and variations in CZ)
- Upper unsaturated zone hydraulic conductivity

In the uncertainty analysis, unlike in the sensitivity analysis, the contaminated zone depth was inversely correlated to the contaminant concentrations, so that choosing different values for the contaminated zone depth did not change the inventory at the site. The NRC staff agreed this approach was appropriate because the total inventory at the site is better known than the contaminated zone depth. The Army also correlated the contaminated zone thickness to the contaminated zone hydraulic conductivity, because the range of values for the contaminated zone depth and was derived, in part, based on how far contamination could travel before the penetrators were completely corroded. The NRC staff determined that this correlation was acceptable because the values selected for modeling the contaminated zone hydraulic conductivity and thickness were chosen together to be consistent with the observed depth of DU migration down from the soil surface.

The NRC staff found that the sensitivity and uncertainty analyses conducted by the Army, with additional analyses conducted by the staff as described in this SER, were appropriate to identify the parameters to which the projected doses were sensitive and to show the uncertainty in the dose estimates due to uncertainty in key parameters. Although the Army's sensitivity analysis neglected an important inverse correlation between the contaminated zone depth and contaminant concentrations, the Army's uncertainty analysis included that correlation. In addition, the Army conducted an additional sensitivity analysis on contaminated zone depth that showed the effect of the parameter on dose. Therefore, the NRC staff found that the purpose of the sensitivity analysis was met because parameters identified as having a significant effect to the projected dose were well-supported by site-specific information, appropriate literature values, or conservative assumptions. In addition, the uncertainty in many of the parameters identified in NUREG/CR-6697 as top priority parameters to test in a sensitivity analysis primarily affect the migration of radionuclides to groundwater. The Army's proposal to monitor groundwater concentrations provides assurance that the dose from the groundwater pathways will not contribute to an exceedance of the dose limits.

In addition to the Army's sensitivity and uncertainty analyses, the NRC staff conducted independent sensitivity and uncertainty analysis to facilitate the review. These analyses are described in the relevant sections of this SER as follows:

- Projected all-pathway TEDE if groundwater concentrations reach 10 CFR Part 20 Appendix B effluent limit concentrations for U-238, U-235, and U-234 on a sum of fractions basis (Section 3.2.1)

- Uncertainty in the projected dose through the inhalation pathway for a hypothetical onsite resident farmer due to uncertainty in the inhalation rate, mass loading for inhalation, mean onsite mass loading, and indoor to outdoor dust concentration

(Section 3.2.8)

- Sensitivity of the inhalation dose to a souvenir hunter due to the air release fraction of corrosion products during sanding or grinding (Section 3.2.9)
- Uncertainty in the projected TEDE to a hypothetical onsite resident farmer due to uncertainty in plant uptake factors and root depth (Section 3.2.10)

3.3 Evaluation Findings

The Army's technical basis for the license amendment request included the evaluation of dose to an onsite industrial worker, an onsite sportsman/recreationalist, a hypothetical resident farmer, and an individual who removes a penetrator from the site and subsequently is exposed to the penetrator throughout the year (i.e., a souvenir hunter). In addition, the Army's technical basis included a proposal to monitor groundwater and surface water with an action level of 5.55 Bq/L (150 pCi/L) for U-238, U-235, and U-234 (applied with a sum of fractions), which represents half of the 10 CFR Part 20 Appendix B effluent limits. The NRC staff evaluated that approach and found it to be acceptable because the combination of dose analyses and monitoring results would address all relevant exposure pathways. The NRC staff found that the range of scenarios and pathways the Army evaluated was acceptable because it was consistent with the site characteristics and possible (or conservative) uses of the site.

The NRC staff reviewed and independently verified the hand calculations and model runs provided by the Army as part of its technical basis for the license amendment request. The bounding scenario for onsite exposures was a resident farmer scenario. For groundwater-independent pathways, the NRC staff evaluated the assumptions and parameter values used in the RESRAD-Offsite (Version 2.6) models and found them to be acceptable because they were based on site-specific data, acceptable literature sources, and conservative assumptions. The NRC staff also performed an independent analysis to show that groundwater concentrations of U-238, U-235, and U-234 that meet the 10 CFR Part 20 Appendix B effluent limits (on a sum-of fractions basis) would not cause doses in excess of the 10 CFR Part 20 Subpart D public dose limits. The Army's groundwater action levels for uranium isotopes, as established in the Army's SOP for Environmental Monitoring (Army, 2000), at one half the 10 CFR Part 20 Appendix B liquid effluent limits provide additional assurance the effluent limits and public dose limits will be met. In combination, the Army's analysis demonstrated compliance with the 10 CFR Part 20 Subpart D public dose limits, the 10 CFR Part 20 Appendix B effluent limits, and the 10 CFR 20.1101(d) 10 mrem/yr TEDE air pathway dose constraint that applies to all types of NRC licensed facilities except those subject to 10 CFR 50.34a (considered ALARA).

Results from the Army's hand calculations and RESRAD-Build model runs demonstrated that the dose to an individual who removes a DU penetrator from the site, removes corrosion products by sanding or grinding, and is incidentally exposed to the penetrator and contaminated dust periodically throughout a year is expected to be less than the 10 CFR 20.1301(a)(1) public dose limit of 1 mSv/yr (100 mrem/yr) TEDE. In addition, the analyses demonstrated that the peak external dose rate for a souvenir hunter was demonstrated to be less than the 10 CFR 20.1301(a)(2) limit on external dose rate of 0.02 mSv/hr (2 mrem/hr) and that the combined inhalation and air submersion dose would be less than the 10 CFR 20.1101(d) 10 mrem/yr TEDE air pathway dose constraint that applies to all types of NRC licensed facilities except those subject to 10 CFR 50.34a (considered ALARA).

The NRC staff reviewed and independently verified the Army's model runs for the industrial worker scenario and found the Army's calculations were accurate. The NRC staff also

performed independent calculations of the projected external dose from handling a penetrator to assess against the requirements of 10 CFR 20.1201 for external exposure. The Army's model runs for the industrial worker scenario, combined with the NRC staff's independent calculations of the external dose from handing a penetrator and the Army's proposal to monitor groundwater, demonstrate that the 10 CFR Part 20 Subpart C occupational dose limits and the 10 CFR Part 20 Subpart D public dose limits would all be met for the onsite industrial worker. The NRC staff evaluated the dose projections for the industrial worker scenario against the criteria for internal and external individual dose monitoring in 10 CFR 20.1502 and found there is no need for individual internal dose monitoring. The NRC staff also compared the dose projections to the 10 CFR 20.1208 dose limit for a declared pregnant woman. The NRC staff found the projected dose is significantly less (i.e., less than 10 percent) of the applicable dose limit and it is highly unlikely the dose limit could be exceeded.

3.4 Conclusions and Proposed License Conditions

3.4.1 Conclusions

The NRC staff concludes that the dose modeling the Army completed is reasonable and is appropriate. The NRC staff evaluated the Army's proposed approach to demonstrate compliance with a combination of dose analyses and a proposal to monitor groundwater and found that approach to be acceptable. The NRC staff evaluated the range of land uses and pathways considered and found them acceptable. The NRC staff performed independent calculations of the projected dose for an industrial worker, sportsman/recreationalist, and for an individual who removes a penetrator from the site and found the Army's dose calculations were performed accurately. The NRC staff also performed independent calculations for an onsite resident farmer scenario and found that the Army's assessment of the water-independent doses was performed accurately and that the groundwater-dependent doses were adequately addressed by groundwater monitoring.

The dose analyses support the NRC staff's decision to not require environmental monitoring of the air or biota on a regular basis. The NRC staff's analysis was based in part on the Army's proposed monitoring of groundwater.

The NRC staff concludes that Army's analysis demonstrates the 10 CFR Part 20 Subpart C occupational dose limits, the 10 CFR Part 20 Subpart D public dose limits, and the 10 CFR 20.1101(d) ALARA constraint on dose from the air pathway will be met. Based on that demonstration, the NRC staff concludes that the license amendment to change License No. SUB-1435 from "possession only for decommissioning" to "possession only" would not endanger life, in partial fulfillment of the requirements in 10 CFR 40.14 for specific exemptions from 10 CFR Part 40.

3.4.2 Proposed License Condition

The Army's approach to compliance with the regulatory requirements in Section 3.1 relied, in part, on groundwater monitoring. In the Army's response to NRC RAIs dated May 25, 2018 (ADAMS Accession No. ML18156A002), the Army proposed to add information regarding groundwater monitoring to the ERMP (in a subsequent revision to the ERMP that was submitted with the 2016 license amendment request). A license condition is needed to ensure groundwater monitoring is performed because groundwater monitoring was used as part of the basis for compliance with the 10 CFR Part 20 Appendix B effluent limits and the 10 CFR Part 20 Subpart D public dose limits.

The Army's Standard Operating Procedure for environmental monitoring (Army, 2000) establishes an action level of 5.55 Bq/L (150 pCi/L) for total uranium in groundwater or surface water. However, that action level was not included in the language the Army proposed to add to the ERMP in the Army's response to NRC RAIs dated May 25, 2018. To address this issue, the NRC staff proposes to add language regarding the action level as a new license condition 15 to be included in the license (See Section 6.0).

4.0 Environmental Radiation Monitoring Plan

As part of the license amendment request (Army, 2016), the Army submitted the ERMP for the DU Impact Area at JPG that contains general commitments for environmental monitoring of those transport pathways justified as having potential significance for the transport of DU contamination outside of the designated DU Impact Area. This ERMP replaces all previous field sampling requirements. The purpose of the previous Field Sampling Plan was for site characterization in anticipation of meeting the decommissioning requirements in the current license. With this license amendment request, the purpose of environmental radiation monitoring changes from site characterization to effluent monitoring. Further, the license institutional controls will include semi-annual surface water, sediment, and groundwater sampling. The Army will remain responsible for remediation of all DU contamination from the impact area north of the firing line.

4.1 Regulatory Requirements

The following regulations apply to the applicant's environmental monitoring program:

- 10 CFR Part 20, Subpart C, "Occupational Dose Limits": 20.1201 – 1208 provides occupational dose limits, radiation exposure requirements, and information on dose limits to an embryo/fetus

- 10 CFR Part 20, Subpart D, "Radiation Dose Limits to Members of the Public": 20.1301 – 1302 establishes the dose to the public from licensed material

- 10 CFR Part 20, Subpart F, "Surveys and Monitoring": 20.1501 and 20.1502 provides survey and monitoring requirements and details on conditions requiring individual monitoring of external and internal occupational dose

- 10 CFR Part 20, Subpart I, "Storage and Control of Licensed Material": 20.1801 and 20.1802 establishes requirements to maintain control of licensed material

- 10 CFR Part 20, Subpart L, "Records": 20.2101 – 20.2110 provides information on the types of radiation safety records that must be kept and their retention requirements

- 10 CFR Part 20, Subpart M, "Reports": 20.2201 – 20.2207 provides information reporting requirements related to incidents, exposure monitoring, and loss/transfer of materials

- 10 CFR Part 20, Appendix B, Table 1, "Occupational Values," provides allowable occupational values of Annual Limits on Intake and Derived Air Concentrations, effluent concentration limits, and allowable concentrations for release to sewers

4.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR Part 20, "Standards for Protection Against Radiation."

4.3 NRC Staff Review and Analysis

As part of its review of the Army's 2016 license amendment request, the NRC staff also reviewed the Army's ER (Army, 2013b) and the Army's DP (Army, 2013a) for potential significance of any transport of DU contamination outside of the designated DU Impact Area. The information that NRC staff reviewed includes the results from radiological scoping surveys, site radiological characterization, and the ERM Program concerning DU in soil, surface water, sediment, groundwater, and biota surrounding the JPG site.

With the radiological status of DU in various media (soil, sediment, surface water, groundwater, and biota) and potential transport pathways identified in these documents, staff evaluated the ERMP to ensure its adequacy and intended purpose of monitoring potential transport of DU contamination outside the designated DU Impact Area and to ensure that controls are established such that appropriate action is taken should that occur.

4.3.1 Summary of Radiological Scoping Survey Results Inside of the Radiologically Controlled Areas

The Army began to evaluate the potential radiological impacts from DU at JPG in 1984, followed by a radiological scoping survey of the DU Impact Area performed in 1994, a radiological characterization survey conducted in 1995, and site characterization activities conducted from 2005 through 2013 (Army, 2013a).

The DU Impact Area, a 2,080-acre (8.4 km^2) area, includes the trajectories from the firing line and locations with DU penetrators within the JPG installation boundary (Figure 1-2). The radiation survey of the DU Impact Area was described in the scoping survey report (SEG, 1995). A summary of results from soil, groundwater, surface water, sediment, and vegetation samples are provided in Table 4-1.

Table 4-1. Scoping Survey Sample Results

Sample Location	Number of Samples	Total Uranium Range in Concentration
DU Impact Area and Environs Soil	50	1.35-201 pCi/g
Sediment	11	0.42-1.9 pCi/g
Surface Water	12	0.21-3.6 pCi/L
Vegetation	14	0.01-0.50 pCi/g
Trajectory Locations Soil	12	1.42-1.87 pCi/g
Sediment	2	2.03-3.08 pCi/g
Surface Water	2	0.35-0.88 pCi/L
Groundwater	11	0.43-3.6 pCi/L
Vegetation	20	0.06-0.65 pCi/g

4.3.2 Summary of Characterization Survey Soil, Vegetation, and Biological Results

The characterization survey was completed after the scoping survey to further define the DU affected area, including exposure rate and gamma spectrometry measurements and environmental medium sampling (soil, groundwater, surface water, sediment, and biota). Analytical results of all samples analyzed by alpha spectrometry are presented in Table 4-2, with details provided in the characterization survey report (SEG, 1996).

Table 4-2. Summary of Characterization Survey Results

Environmental Medium (depth in cm)	Number of Samples	Total Uranium Range in Concentration (pCi/g)	Average Concentration (pCi/g)
Background samples: 0-15	10	1.52-2.53	1.97
15-30	10	1.33-2.59	1.84
30-45	10	1.33-2.76	1.95
Penetrator Soil Samples: 0-15	20	2.9-12,318	2,881
15-30	20	1.5-547	79.5
30-45	20	1.8-63	12.7
45-60	13	1.4-11.5	4.50
Random Soil Samples: 0-15	20	1.46-4.73	2.60
15-30	20	1.51-6.91	2.40
30-45	20	1.34-4.21	2.00

The characterization survey results show that the impact of DU on soil was limited to the area surrounding the DU penetrators. The highest total uranium concentrations were found in the near surface soil surrounding the penetrators, with up to 12,318 pCi/g above the background level of approximately less than 3 pCi/g. The impact of DU in soil was detected up to approximately 60 cm depth below the land surface in the impact area with penetrators.

As part of the characterization survey, 10 vegetation samples (lichens, leaves, and grass) were collected from the DU affected area trenches. The total uranium concentration in vegetation samples varied from 0.75 to 3,447 pCi/g, with an average concentration of 627.5 pCi/g. The wash samples were found with a total uranium concentration from 46.1 to 14,258 pCi/g, with an average concentration of 2,869 pCi/g. Based on the isotopic composition of natural uranium and DU (U-234, U-235, and U-238) and their radioactive characteristics, the Army determined that a U-238/U-234 ratio of 2.0 or less was considered representative of natural uranium, whereas higher ratios are indicative of DU contamination. The measured U-238/U-234 activity ratio in the vegetation samples ranged from 6.1 to 8.4, indicating the presence of DU contamination.

In addition, a total of eight biological samples were collected from deer, freshwater clams, fish, and a soft-shelled turtle during the characterization survey. The total uranium concentrations ranged from 0.09 to 0.42 pCi/g in deer samples, 0.33 to 0.77 pCi/g in freshwater clams, and

were below 0.25 pCi/g in fish and turtle. There is no indication of presence of DU contamination in the collected biological samples as the U-238/U-234 activity ratios were found between 0.4 and 1.2. The Army also implemented a comprehensive program to assess the uptake of uranium by deer present on the installation during the winter of 2005/2006. A total of 132 tissue samples were from 30 deer present on the installation and analyzed for uranium. DU was not detected in any deer tissue sample. Therefore, the Army concluded, and NRC agreed, that the potential uptake of uranium as a result of deer meat consumption by hunters does not represent a potentially significant exposure pathway at JPG.

4.3.3 Surface Water and Sediment Monitoring

NRC Staff reviewed the Army's ER (Army, 2013b) for potential significance of any transport of DU contamination outside of the designated DU Impact Area in surface water and sediment.

4.3.3.1 Surface Water and Sediment Monitoring Methodology

Surface water features located at the Army's installation include streams with their tributaries, namely Otter Creek, Graham Creek, Little Graham Creek, Marble Creek, Big Creek, Middle Fork Creek, and Harberts Creek, Old Timbers Lake, and wetland areas. The DU Impact Area is only incised by Big Creek and Middle Fork Creek with their tributaries. Big Creek originates offsite and flows 9.2 stream mi (14.8 km) across JPG, and Middle Fork Creek originates on JPG and meanders 2.6 mi (4.2 km) across the facility. Both streams are fed by numerous intermittent tributaries and have sand/gravel substrate with bedrock visible on the bottom and along the banks in many locations JPG, including the DU Impact Area. Stream stage data collected at gauging stations installed in both Big Creek and Middle Fork Creek and the corresponding manually measured flow rates show that the stream flows increase and decrease rapidly in response to surface runoff during precipitation events. Transport of DU either through sediments with DU attached and/or disintegrated DU particles by moving with surface runoff and stream flow may represent a significant potential pathway for the migration of DU from the DU Impact Area. Observation data show that a period of low to no-flow occurs for 4 to 6 weeks during June and July of each year. During low flow period, the stream is likely fed primarily by groundwater discharge.

Surface water and sediment samples have been collected in Big Creek and Middle Fork Creek and their tributaries and analyzed for uranium during the radiological scoping and site characterization surveys, and in the Environmental Radiation Monitoring Program (ERM Program).

- Radiological Scoping and Characterization Survey: The survey of the facility operation, the firing lines, and DU Impact Area was conducted in October and December 1994 to determine the areas impacted by the DU projectiles. Surface water and sediment samples collected in the site Characterization Survey include locations upstream of Big Creek, within and downstream of Big Creek from the DU Impact Area, and locations in Middle Fork Creek within and downstream from the Firing Line Area (SEG, 1996). As part of the scoping survey, 14 surface water samples and 13 sediment samples were collected.

  The scoping survey confirms the classification of the DU Impact Area as a radiologically affected area where a 1,300-ac (5.3 Km^2) portion of the DU Impacted Area may potentially contain UXO. A more detailed radiological characterization of the DU Impacted Area was performed in 1995 (SEG, 1995).

- ERM Program: The ERM program, initially developed before the DU munitions testing in 1984 and updated in 1996 and again in 2000, outlined the strategy and associated procedures for biannual sampling of environmental media within and surrounding the DU Impact Area at JPG, and provided the basis for determining if DU was present in the monitored media and risks to receptors from potential exposure to DU (Monsanto, 1984; Army, 1996). Based on the ERM program, surface water sampling was conducted from 8 sampling locations (SW-DU-001 to SW-DU-008) from December 2004 through October 2012, with a total of 145 discrete surface water samples (including duplicates). During the sample time period, 151 sediment samples (including duplicates) were collected from 8 sampling locations (SD-DU-001 to SD-DU-008).

- Site Characterization Program: Surface water samples were collected from April 2008 and February 2009 from expected mixing zones, caves, and seeps along Big Creek, Middle Fork Creek, and the northern tributary of Big Creek based on a stream survey conducted from February to April 2008 (Army, 2013b). The sampling locations are upgradient of the DU Impact Area, within the DU Impact Area and near and downgradient from areas with the highest suspected sources of DU, and downgradient from the DU Impact Area. In total, 118 surface water samples (filtered and unfiltered) were collected from Big Creek, and 35 samples (filtered and unfiltered) from Middle Fork Creek, and 21 samples (filtered and unfiltered) from the northern tributary of Big Creek. Samples were analyzed for total and isotopic uranium among other parameters. Sediment samples were also collected and analyzed for total and isotopic uranium from 20 primary locations selected based on the characteristics of hydrology and channel morphology along Big Creek, Middle Fork Creek, and North tributary.

4.3.3.1.1 Results of Surface Water Sampling

In the scoping survey conducted in 1994, total uranium measured in the surface water samples varied from 0.21 pCi/L upgradient to 4.11 pCi/L within and downgradient from the DU Impact Area, with ratios of U-238 to U-234 being near unity. A slightly higher background total uranium of 0.62 pCi/L was detected in Big Creek upstream of the DU Impact Area in the characterization survey. During the characterization survey conducted between April 2008 and February 2009, the total uranium concentration varied from 0.77 to 25.02 pCi/L in surface samples collected from Big Creek within the DU Impact Area, and the average of total uranium concentration in surface water was 0.89 pCi/L on the western boundary of the installation. The total uranium in surface water samples collected from Middle Fork Creek ranged from 0.63 to 1.80 pCi/L. Among all samples, only two sampling locations of static pools of water within the DU Impact Area were identified with higher than background total uranium concentrations. The U-238/U-234 activity ratios in the samples from static pools of water were 4.4 and 7.3, indicating the presence of DU.

Surface water samples collected in the ERM Program from December 2004 to October 2012 had an average total uranium activity at 0.88 ± 2.4 pCi/L, with the maximum detected uranium activity of 19 ± 2pCi/L. In addition, surface water monitoring was performed between 2008 and 2009 in a site characterization program. Quarterly surface water samples were collected between April 2008 and February 2009 from 20 primary and/or pre-determined alternative locations along Big Creek and its norther tributary, and Middle Fork Creek. Total uranium

concentrations ranged from 0.032 ± 0.14 to 22 ± 4.4 pCi/L, with an average concentration of 1.2 pCi/L. Based on the elevated U-238/U-234 ratios (i.e., exceeding 3.0), DU appeared to be present in surface water in one or more of the quarterly site characterization samples. The majority of the water samples with elevated uranium isotopic ratios were collected during July 2008 from Big Creek, especially in close proximity to the trench associated with the 500 Center line of fire. The samples with higher uranium concentrations were generally associated with the lowest stream flow condition in Big Creek and/or Middle Fork Creek (e.g., sampling from standing pools of water).

The Army's statistical analysis indicates that total uranium in the surface water samples generally were about twice as high within the DU Impact Area as compared to background and were significantly higher in the summer than at other times (Army, 2013b). Based on its review, NRC staff found that all the available total uranium concentrations of surface water samples collected at the JPG facility have been significantly below the 150 pCi/L action level for surface water.

4.3.3.1.2 Results of Sediment Sampling

The total uranium concentrations ranged from 0.42 pCi/g to 1.9 pCi/g in the sediment samples collected inside the DU Impact Area, and from 2.03 pCi/g to 3.08 pCi/g in the trajectory locations during the scoping survey conducted in 1994. In the characterization survey performed between 2008 and 2009, the sediment sample collected from Big Creek in the east boundary of JPG (upstream from the DU Impact Area) had a total uranium of 0.78 pCi/g. The total uranium concentration in the sediments within the DU Impact Area ranged from 0.75 to 6.20 pCi/g in Big Creek and varied from 2.23 to 3.46 pCi/g in the Firing Line area in Middle Fork Creek. The total uranium concentration in the sediment on the western perimeter was 0.75 pCi/g in Big Creek and 1.81 pCi/g in Middle Fork Creek.

Sediment samples were collected in the ERM program from eight locations from December 2004 through October 2012. The average total uranium activity from these samples was 0.97±0.49 pCi/g, with the maximum at 2.4±0.4 pCi/g. Review of all available uranium concentrations in sediments collected from the scoping survey, characterization survey, and the ERM program indicates that although there was evidence of DU in the sediments based on elevated U-238/U-234 ratios, the total uranium concentrations at each sampling location were below the 35 pCi/g action level, which has historically been regarded as the derived concentration guideline level (DCGL) for uranium in surface soil.

Surface water samples that were identified with elevated U-238/U-234 ratios (ranging from 1.7 to 7.79) during the quarterly site characterization and ERM sampling events that occurred from 2006 to 2012 were mostly collected in the 4th Quarter (October), with fewer samples in the 2nd Quarter (April) from Big Creek (e.g., from location SW-DU-005, SW-DU-004, and SW-DU-008), especially in close proximity to the trench in connection to the 500 Center line of fire (e.g., SW-DU-005). Fewer elevated U-238/U-234 were associated with samples collected from Middle Fork Creek and North Tributary. The 4th Quarters are generally associated with low flow conditions, with most of the water likely contributed from base flow (or groundwater) and springs and seeps along the river bank, and possibly some overland flow. During the period of low flow, most of these water sources contributing to the creeks within the DU Impact Area have likely been in contact with penetrators and DU impacted soils near the land surface.

The other major factor resulting in the observed higher U-238/U-234 ratios and total uranium concentrations in surface water samples is the lack of significant dilution by water coming down from upgradient of the DU Impact Area in the creeks. The NRC staff further noted that surface water samples with higher U-238/U-234 ratios generally also have higher total uranium concentrations due to the same uranium source (DU). Higher or intensive precipitation that normally occurs during the spring may have resulted in significant overland flow. The overland flow may have caused significant soil erosion and therefore transported DU impacted soil from the DU Impact Area into Big Creek, Middle Fork Creek, and their tributaries. Based on review of all available collected sediment data, the NRC staff found evidence of the presence of DU in some of the sediment samples, but the total uranium concentrations detected are significantly below the 35 pCi/g action level around the JPG facility.

Given the site hydrological characteristics and the objective of this license amendment request, the NRC staff finds that the Army's semi-annual monitoring of surface water and sediment during the high and low-flow seasons (e.g., generally spring and fall) at Big Creek and Middle Fork Creek immediately downgradient of the DU Impact Area and further downgradient at the western JPG facility boundary are acceptable and adequate because the proposal is able to monitor the extreme scenarios of likely high uranium concentrations, including contribution from North Tributary covering the northern portion of the DU Impact Area (through sampling of Big Creek at the western boundary of the JPG installation).

4.3.4 Groundwater Flow System and Monitoring Results

In the process of evaluating the Army's revised groundwater monitoring plan as described in the Army's response to NRC RAIs (ADAMS Accession No. ML18156A002), the NRC staff reviewed site conceptual hydrogeological model and its supporting site characterization data, groundwater flow modeling results and groundwater age data.

The local groundwater system in which potential transport of DU occurs in groundwater from the DU Impact Area consists of overburden, shallow fractured, and a deep, relatively competent carbonate bedrock hydrogeological units. The overburden mainly consists of soil, loess and glacial till (Pre-Wisconsinan till) in the DU Impact Area. The overburden is up to approximately 70 ft. thick and generally decreases from the flat upland areas toward local streams or creeks near which landscapes are deeply dissected with the overburden completely eroded along most of Big Creek, Middle Fork Creek, and other tributaries. The overburden materials are not generally considered as an aquifer due to the lack of extensive presence of coarse grained units (e.g., sand and gravel).

The overburden till is underlain by carbonate rocks, an interbedded limestone, dolomite, and shale (lower sequence of Silurian Age and Ordovician Age (Greeman, 1981)). The Karst features in the carbonate rocks include solution enlarged joints and fractures. Caves are observed along narrow areas close to the entrenched streams of Big Creek and Middle Creek, however, active flowing groundwater has not been observed in all caves (Sheldon, 1997). Evidence of subsurface Karst features beneath the overburden surrounding the DU Impact Area are indicated by the results of fracture-trace analysis (Greeman, 1981; SAIC, 2007) and Electrical-imaging (EI) survey (SAIC, 2007). Data collected from EI survey conducted at the DU Impact Area show the presence of significant fractures in the bedrock, and some of these fractures may have been filled with water or wet-fine sediments. The observation and analysis of fractures in bedrock core samples recovered in the bedrock well locations at the site indicate

that fracturing predominates in shallow bedrock (approximately upper 25 ft. of bedrock), and few fractures in the lower bedrock (beyond about 60 ft.). They also suggest that groundwater flow primarily takes place in the shallow carbonate bedrock where the fractures, joints and possibly conduits are present. As further suggested by the slow recovery water levels in most wells in the deep carbonate unit, groundwater occurrence and flow appear to be very limited as joints and bedding planes are sparse and poorly connected in the deep bedrock.

Based on the site conceptual hydrogeological model discussed above, the occurrence and flow of groundwater within and from the DU Impact Area is expected to mostly take place in the overburden and shallow bedrock zone, with a general groundwater flow in a southwestern direction. Based on the available monitoring data, groundwater elevations within the overburden and shallow zone generally mimic the surface topography. The local groundwater flow directions, however, may vary and generally moves toward Big Creek and Middle Fork Creek, and their tributaries. In the DU Impact Area, north of the Big Creek groundwater moves predominantly south from upland areas, whereas groundwater in the south of Big Creek moves north, both toward the local discharge area of Big Creek (and its tributaries). In the upland area between the Big Creek and Middle Fork Creek there appears to be a groundwater divide, with groundwater moving in opposite directions across the divide. In this case, groundwater in the DU Impact Area south of this divide moves south toward Middle Fork Creek. Within the local aquifer system, groundwater in the upland areas (recharge areas) exhibits predominantly downward but slow movement in the overburden into the shallow carbonate bedrock, and groundwater moves upward near streams (discharge areas). Recharge (or infiltration) that occurs in the DU Impact Area and may potentially contain DU moves slowly but may move more rapidly where the overburden is thin or absent, or other types of preferential flow pathways (e.g., sinkholes) exist.

The Army constructed a finite-difference numerical model to evaluate the groundwater flow in the overburden and shallow bedrock zone around JPG. In the process of developing the groundwater flow model, natural boundaries were used to the extent possible in defining the model domain, including creeks and basin flow divides. A no flow boundary was assumed at the base of the shallow bedrock. Groundwater flow modeling results show groundwater beneath the JPG site generally flows to the southwest with a steep gradient along the creeks, consistent with site observed groundwater elevation data. Most of the groundwater in the modeled domain discharges to the steams with a minor amount exiting the saturated zone through the model boundary. The staff notes that the flow model involved significant assumptions and uncertainties with many of input parameters.

An investigation of the relative age of groundwater was conducted in the overburden till and underlying carbonate bedrock units in and near the DU Impact Area (Buszka, Lampe, and Egler, 2010). Chlorofluorocarbon compound and tritium-based age dates of Pre-Wisconsinan till groundwater varied greatly, ranging from substantially modern (early-1980's) for groundwater in some wells the overburden till to submodern (1953 or older) in the carbonate unit. Areas with groundwater age dates that are near or after the onset (1984) of DU penetrator testing and that are hydraulically downgradient from the DU Impact Area are logical locations for monitoring potential DU migration in the groundwater.

The initial assessment of DU in groundwater was conducted around the DU firing range between 1984 and 1994, with monitoring well depth ranging to more than 40 ft below grade. Total uranium concentrations in the groundwater exhibited large variation, with an average of

2.7±5.6 pCi/L and maximum up to 81 pCi/L due to issues involving analytical laboratories. As part of the scoping and characterization survey conducted in 1994 and 1995, groundwater samples were collected from 11 monitoring wells, and the total uranium in the groundwater samples varied from 0.33 to 5.09 pCi/L, similar to the background levels at the site. Groundwater sampling of these 11 wells continued from late 2004 through late 2012. The average total uranium activity in the groundwater samples collected during this time period was 1.4 ±1.2 pCi/L, with a maximum detected uranium activity of 5.7± 0.6 pCi/L using a revised analytical procedure.

The Army concluded that groundwater presented an "extremely low-risk pathway," based on their transport modeling analysis, and they proposed to conduct limited groundwater monitoring. The NRC staff expressed concerns in a RAI on March 27, 2018 (ADAMS Accession No. ML17341B560) about the long-term potential migration of DU into groundwater due to its long-lived nature and stated that the Army had no current remedial action planned (RAI GW-1) and only limited groundwater monitoring without committing to specific schedules for groundwater monitoring (RAI GW-3). The NRC staff expressed concerns that the Army's transport modeling analysis did not include a systematic consideration of effects, such as the effects on wetlands in the DU Impact Area and variations of depth to water table, especially in the DU trench area where overburden thickness is significantly reduced and large amounts of DU are present. In response to these RAIs, the Army responded that it plans to include semi-annual groundwater monitoring with analysis of total uranium and its isotopes at four (4) locations in the DU Impact Area, MW-DU-001; MW-DU-005, MW-DU-006, and MW-DU-011 (Army, 2018). Groundwater samples will be analyzed for total uranium/isotopic uranium using the same analytical methods and procedures as proposed for surface water in Section 4.3.3.1.

The proposed shallow bedrock monitoring well MW-DU-011 and well MW-DU-005 are located in the central part of the DU Impact Area near Big Creek, and in the shallow carbonate unit near the Big Creek and near the western boundary of DU Impact Area, respectively. In addition, well MW-DU-011 is also close to the DU trenches which are in the central part of the DU Impact Area.

In addition to its downgradient location from the southern portion of DU Impact Area, the recommended overburden well MW-DU-006 was found with substantially modern (post-1953 and possibly post-1972) groundwater based on tritium age dating (Buszka, Lampe, and Egler, 2010). The relative modern groundwater indicates recent recharge originating at the land surface from precipitation. MW-DU-001, a shallow bedrock well also being selected for groundwater monitoring, is situated on the eastern side of the DU Impact Area and has historically detected with elevated U-238/U-234 activity ratios. This elevated U-238/U-234 activity ratios are likely associated with the DU at JPG.

Overall, the proposed four (4) monitoring wells are generally located downgradient from the DU Impact Area in the overburden and shallow bedrock zones and have historically detected the presence of DU in the groundwater. The NRC staff finds that the proposed monitoring wells with a semi-annual sampling schedule is acceptable and believes that the Army's groundwater monitoring commitment (Army, 2018) will serve the purpose of detecting future potential migration of DU in groundwater from the DU Impact Area.

4.3.5 Air Sampling

In the ERMP (Army, 2018), the Army does not propose to take samples for air monitoring. Section 3.2.8 of this SER supports the conclusion that air monitoring is not needed to monitor airborne effluents under routine conditions because (1) the projected dose from those effluents is expected to meet the 10 CFR 20.1101(d) 0.10 mSv/yr (10 mrem/yr) limit on the projected dose from air emissions (excluding Radon-222 and its progeny) for an onsite resident and (2) unmonitored air effluents are unlikely to exceed 30 percent of the total estimated effluent releases or 10 percent of the permissible air effluent concentrations found on column 1 of Table 2 in 10 CFR Part 20, Appendix B, whichever is greater, consistent with the monitoring guidance in NUREG-1556, Volume 7. In addition to the routine releases evaluated in the context of an onsite resident scenario in Section 3.2.8 of this SER, this section also evaluates the potential for airborne releases of DU due to controlled burns and detonation of explosives in the DU Impact Area.

In 2008, an Atomic Safety and Licensing Board decision (NRC, 2008) addressed site characterization and environmental monitoring at JPG during an alternative decommissioning period. In that decision, the Board determined that the Army decision not to include air sampling at JPG was reasonable during the alternative decommissioning period because of the low risk posed by airborne effluents from the site, including during controlled burns. The Board cited three lines of evidence to support that decision: (1) previous air monitoring results from JPG, (2) air monitoring results from Los Alamos National Laboratory (LANL), and (3) other studies cited by the Army, including a modeling study (Argonne, 1998) cited in a 2005 memo from an Army contractor (Shia, 2005).

The Army monitored particle-associated uranium in air at JPG during controlled burns in February 1984, April 1985, January 1986, and October 1987 (Army, 1989). The air filters were positioned near the DU Impact Area at the intersections of C Road, D Road, Wonju Road, and Morgan Road. Uranium was not detected in any of the filters. The lower detection limit achieved during those tests is unclear because the Army did not provide the duration of sampling or estimate the volume of air sampled (Army, 1989).

As previously mentioned, the Board also considered information from a fire at LANL in 2000. The study from LANL (Whicker et al., 2006) compared measurements taken before and after the fire to determine the effect of increased wind-blown dust due to vegetation changes caused by the fire (i.e., not smoke from the fire). Another study (Kraig, 2001) evaluated measurements of airborne uranium taken during the fire. That study showed that the projected doses to offsite residents and LANL workers onsite during the fire were less than 1 mrem. However, although the amount of DU on the LANL site is comparable to the amount of DU on the JPG site, neither the Army nor the cited reports indicated whether the amount of DU on the 30 percent of the LANL site that burned was comparable to the amount of DU at JPG.

The information from the contractor memo (Shia, 2005) was discussed in the Army's DP (Army, 2013a). Specifically, both the Army's DP and the Shia, 2005 memo discussed the results of a mathematical model of uranium release in smoke from controlled burns at Aberdeen Proving Ground. That study (Argonne, 1998) represented root uptake of DU into plants and subsequent

transport of that DU in smoke when the plants burned (i.e., modeled, not measured, concentrations of DU in plants). As part of the NRC staff's review for the possession-only license amendment, the NRC staff considered the how measured concentrations of DU in plants from JPG (Army, 2013a) would affect the model results of Argonne (1998).

In its ER (Army, 2013b), the Army supplied site-specific measurements of DU in vegetation from random locations in the DU Impact Area, from locations along firing lines, and from locations within 0.9 meters (3 feet) of a penetrator. The concentrations in plants from along the firing line were greater than the modeled values of Argonne (1998) (i.e., 0.04 pCi DU/g plant in the Argonne study as compared to a measured range of 0.06 to 0.65 pCi DU/g plant at JPG). Although the Army measured larger concentrations in plants within 1 meter (3 feet) of a penetrator, those concentrations are not expected to be representative of the average plant concentration in the DU Impact Area. The NRC staff, therefore, used the largest value measured in a plant at a random location along the firing line as an estimate of the average value of DU in plants in the DU Impact Area. When substituted into the air dispersion calculations of Argonne (1998), that value (i.e., 0.65 pCi DU/g plant) resulted in a dose of less than 1 mrem/yr (i.e., 0.2 mrem for 6 hours of smoke exposure at the ground location with the highest smoke exposure).

The original references (SEG, 1995; SEG, 1996) for the plant concentration measurements that were provided in the Army's ER indicated that the plants had been washed prior to measurement. Therefore, the measurements do not include the potential contribution of uranium deposited on the leaves. Although measurements are not available for the amount of DU deposited on the plant leaves, data from "root washes" provided in the ER indicate that the concentration could be approximately five times greater than the concentration in the leaves. That estimate is expected to be a conservative bound on the relative concentration of uranium on the leaves because more soil is expected to cling to the roots than the leaves. Increasing the projected dose by a factor of six to account for DU on the leaves as well as in the leaves would yield a projected dose of approximately 1 mrem/yr for six hours of smoke exposure at the location with the highest smoke concentration for an offsite resident.

In addition to DU in smoke from burned plants, the NRC staff independently considered inhalation of contaminated dust suspended by convective forces created by the fire. To bound the potential dose from inhalation of contaminated soil suspended by convective forces of a fire, the NRC staff considered an air particulate loading of 301 micrograms per cubic meter of air and assumed the entire mass corresponded to the soil source. That value corresponds to "hazardous" conditions, above which emergency notifications of nearby populations would occur (EPA, 2016). The NRC staff selected that value as a conservative estimate of the potential particle loading during a controlled burn because emergency notifications of hazardous conditions have not been triggered by controlled burns at JPG. Using that conservative estimate of mass loading, the NRC staff independently calculated a conservative projection[10] of

[10] The NRC staff assumed a uranium concentration on particle matter equal to the maximum soil concentration in the primary contamination zone portion of the DU Impact Area (i.e., conservatively estimated in the Army's RESRAD analysis as 500 pCi DU/g soil), an exposure duration of 5 hours, an inhalation rate of 0.05 m^3/min (i.e., corresponding to the mean breathing rate for heavy activity for a 21-30

less than 1 mrem dose per 5-hour exposure to smoke from a fire at JPG. Therefore, after the NRC staff updated the results of the Argonne study (1998) with measured values of DU concentrations in plants from JPG, consideration of DU deposited on plant leaves, and inhalation of contaminated soil, the NRC staff concludes that controlled burns at JPG pose minimal risk to the public and do not necessitate air monitoring at JPG.

The DP for JPG did not specifically address the potential effects of explosions on airborne emissions of DU except to note the potential for DU contamination to be spread by UXO detonation (DP, Section 4.3.2.1). Explosions in the DU Impact Area are not expected to be a routine occurrence because JPG is no longer an active Army proving ground. Furthermore, although the INANG maintains two active bombing ranges at JPG,[11] as explained in Section 2.7 of the DP, the INANG air-to-surface firing is limited to inert munitions with spotting charges and laser energy (i.e., no explosive warheads are used). Therefore, the NRC staff expects explosive disruption of DU at JPG to be limited to detonation of UXO in the DU Impact Area, which the NRC staff expects to be an infrequent event. The NRC has not previously required air monitoring at JPG to address that scenario.

To evaluate the potential dose to an individual downwind of a UXO explosion in the DU Impact Area, the NRC staff considered studies of potential inhalation doses downwind of DU fires and explosions at other sites that involved DU. For example, the Army estimated that the potential inhalation dose to an individual at the point of highest concentration downwind of the fire and UXO explosions at Camp Doha, Kuwait, would receive 0.003 mrem if smoke was breathed in for 24 hours (USACHPPM, 2000). That dose is expected to conservatively overestimate the potential dose from a UXO explosion at JPG because it involved several UXO explosions and a lengthy (i.e., 24-hour) resulting fire. In addition, the source term for that fire was approximately 3,100 kg DU, which is significantly greater than the source term the NRC staff expects to be present in a UXO explosion at JPG[12]. Therefore, based on consideration of (1) routine conditions (2) controlled burns and (3) explosion of UXO, the NRC staff finds that air sampling is not necessary to demonstrate compliance with the 10 CFR 20.1101(d) 0.10 mSv/yr (10 mrem/yr) limit on the projected dose from air emissions (excluding Radon-222 and its progeny) for an onsite resident. In addition, as discussed in Section 3.2.8, the NRC staff finds that any air effluents are unlikely to exceed 10 percent of the permissible air effluent concentrations found on column 1 of Table 2 in 10 CFR Part 20, Appendix B, consistent with the monitoring guidance in NUREG-1556, Vol. 7.

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year old individual), and an inhalation dose conversion factor from Federal Guidance Report No. 11 corresponding to the most restrictive solubility class.

[11] As shown in Figure 3-2 in this SER, the bombing ranges do not intersect the DU Impact Area; however, the safety fan of the smaller of the two ranges does include the DU Impact Area.

[12] For example, the NRC staff considered a hypothetical UXO explosion that affected an area with a radius of 8 m (26 ft) and area of 200 m^2 (2100 ft^2). The most contaminated part of the DU Impact Area is the DU trench in 500 Center line of fire north of Big Creek, which is 2.5 x 10^4 m^2 (6.2 acres) and contains 13,600 kg of DU (DP, Table 1-6, footnote a), or approximately 0.54 kg DU/m^2. Assuming the hypothetical UXO explosion occurred in that DU trench, it would affect 110 kg DU (i.e., 0.54 kg DU/m^2 multiplied by 200 m^2 affected area).

4.4 Conclusions and Proposed License Conditions

4.4.1 Conclusions

The results of the scoping survey, site characterization, and ERM Program show that air, soil, and biota do not represent a concern as exposure pathways for DU at JPG. The dose assessment performed by the Army and independently performed by NRC staff (Section 3.0) support the conclusion that monitoring of air, soil, and biota are not required provided the Army conducts regularly scheduled monitoring of water pathways at the site as proposed in its license amendment request to change License No. SUB-1435 from "possession only for decommissioning" to "possession only", dated December 21, 2016 and supplemented on May 25, 2018.

The NRC staff reviewed site characterization and monitoring data related to assessing the potential leaching of DU from the remaining DU penetrators and their corrosion products in the DU Impact Area into the environment via water pathways (surface water, sediments and groundwater) at JPG. The staff concludes that the Army's investigations, including methods ranging from soil and monitoring well installations in unconsolidated glacial till overburden and in shallow and deeper carbonate units, geophysical survey, fracture trace analysis, and groundwater age determination and analysis are appropriate and adequate. The NRC staff further find that the Army is in compliance with 10 CFR Part 20 Subpart D because the monitored concentrations of DU in surface water and groundwater are significantly below the effluent concentration limits for protection of individual members of the public (Table 2 of Appendix B, 10 CFR Part 20).

In support of its license amendment request, the Army proposed surface water and sediment monitoring that consists of collocated sampling at immediate downstream locations from the DU Impact Area in the Middle Fork Creek (SW-DU-007/SD-DU-007) and Big Creek (SW-DU-008/SD-DU-008), and at locations further downstream from the DU Impact Area in Middle Fork Creek (SW-DU-001/SD-DU-001) and Big Creek (SW-DU-002/SD-DU-002) at the western boundary of JPG. Surface water and sediment sampling will be conducted semi-annually (generally in the spring and fall near hydraulic high and low) and analyzed for total uranium and isotopic composition.

The Army has also committed to a semi-annual groundwater sampling with analysis of total uranium and its isotopes at four (4) locations in the DU Impact Area: MW-DU-001, MW-DU-005, MW-DU-006, and MW-DU-011 to monitor potential DU transport in groundwater from the DU Impact Area. The proposed monitoring locations are based on the site conceptual hydrological and hydrogeological model that are supported by the site characterization data. The proposed groundwater monitoring wells for monitoring were selected because of elevated historical U-238/U234 activity ratios identified during previous ERM Program sampling, being located in the shallow carbonate unit near stream with thin overlying or more permeable till, and hydraulically downgradient from or close to the DU Impact Area, and groundwater identified as substantially modern (post-1953 or possibly post-1972). The NRC staff verified that these proposed groundwater monitoring wells are situated in the active zones (based on groundwater age assessment data) of hydraulically downgradient of the DU Impact Area as indicated by the collected groundwater level measurement data.

The NRC staff also concludes that the proposed semi-annual surface water, groundwater and

sediment sampling schedules are reasonable and acceptable because the detected uranium concentrations have been low relative to the background levels and have not shown significant temporal changes to date. To comply with 10 CFR 20.1301, "Dose limits for Individual members of the public," and 10 CFR 20.1302, "Compliance with dose limits for individual members of the public," the Army proposed to conduct surface water and groundwater with a 150 pCi/L action level, which is one half of the value specified in Table 2 of Appendix B to Part 20, and sediment monitoring with a 35 pCi/g action level. In addition, the Amy has met the requirement described in 10 CFR Part 20, "Surveys and Monitoring," § 20.1501, "General," by conducting scoping survey, characterization survey, and ERM sampling to determine the magnitude and extent of radiation levels in various media (soil, surface water, groundwater, air, and sediment) at JPG.

The NRC staff concludes that Army's analysis and technical basis complies with the regulatory requirements identified in Section 4.1 and that the Army has adequately identified pathways of DU transport and conceptual site hydrologic and hydrogeological models that are supported with adequate site characterization and historical monitoring data. Based on its evaluation, the NRC staff find that the Army's proposed surface water, sediment, and groundwater monitoring programs are reasonable and acceptable, and the NRC staff concludes that the license amendment to change License No. SUB-1435 from "possession only for decommissioning" to "possession only" would not endanger life, in partial fulfillment of the requirements in 10 CFR 40.14 for specific exemptions from 10 CFR Part 40.

4.4.2 Proposed License Condition

Consistent with Section 3.4.2 of this SER, the NRC staff proposes license condition 15 (See Section 6.0) to be included in the license, as proposed in the Army's responses to NRC RAIs (Army, 2018).

5.0 Financial Assurance

The Army's license amendment request (Army, 2016) includes a decommissioning funding plan (DFP) and SOI to request funds.

5.1 Regulatory Requirements

10 CFR 40.36, "Financial Assurance and Recordkeeping for Decommissioning" establishes the financial assurance and recordkeeping requirements for source material licensees.

Applicable provisions under 10 CFR 40.36 are as follows:

10 CFR 40.36(a) states that "each applicant for a specific license authorizing the possession and use of more than 100 mCi of source material in a readily dispersible form shall submit a decommissioning funding plan described in [10 CFR 40.36(d)]."

10 CFR 40.36(c)(5) states that "if, in surveys made under 10 CFR 20.1501(a), residual radioactivity in the facility and environment, including the subsurface, is detected at levels that would, if left uncorrected, prevent the site from meeting the 10 CFR 20.1402 criteria for unrestricted use, the licensee must submit a decommissioning funding plan within one year of

when the survey is completed."

10 CFR 40.36(d) requires that every decommissioning funding plan, be submitted for NRC review and approval, and must contain a detailed cost estimate for decommissioning that includes: costs based on an independent contractor; cost of meeting 10 CFR 20.1402 criteria for unrestricted use; volume of onsite subsurface material that contains residual radioactivity requiring remediation; an adequate contingency factor; identification and justification for key assumptions; description of method for assuring decommissioning funds; certification of financial assurance; and a signed original, or copy (if permitted) of the financial instrument being used.

10 CFR 40.36(e)(4) requires that a governmental entity who uses a statement of intent for financial assurance must include a cost estimate for decommissioning and indicate that funds for decommissioning will be obtained when necessary.

5.2 Regulatory Acceptance Criteria

The license amendment request was reviewed for compliance with the applicable requirements of 10 CFR 40.36," Domestic Licensing of Source Material," and for consistency with guidance in NUREG-1556, Vol. 7, Section 8.5.2: "Financial Assurance and Recordkeeping for Decommissioning", and NUREG-1757, Vol. 3, Rev. 1, "Consolidated Decommissioning Guidance: Financial Assurance, Recordkeeping and Timeliness, Rev.1" (NRC, 2012).

5.3 NRC Staff Review and Analysis

The Army's DFP includes a detailed site-specific cost estimate prepared based on analyses performed using The Remedial Action Cost Engineering and Requirements (RACER®) software[13]. The estimate includes costs for decommissioning tasks related to: planning and preparation; decontamination or dismantling of radioactive facility components; final radiation safety, restoration of contaminated areas on facility grounds; and site stabilization and long-term surveillance. Costs associated with packaging, shipping, and disposal of radioactive wastes are included under the decontamination or dismantling of radioactive facility components task.

The Army states that the cost estimate for all decommissioning activities is based on the work being performed by an independent contractor and does not take any credit for any salvage value the Army might realize from the sale of potential assets.

The Army's DFP also states that the site-specific cost estimate was developed to cover all phases of decommissioning of the DU Impact Area to meet unrestricted release criteria in 10 CFR 20.1402.

The DFP states that approximately 73,500 kg (162,000 lbs) of DU remains in the DU Impact Area. A geographic information system (GIS) modeling approach was used to estimate the spatial distribution of residual DU within the DU Impact Area. Based on the spatial analysis

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[13] RACER® software is a Windows®-based environmental remediation/corrective action cost estimating software. The RACER software estimates costs for all phases of environmental remediation projects – from site investigation through site closeout. This software is licensed and developed by Asset Management Division (AECOM). For more information refer to racer@AECOM.com

performed, the Army estimates that the primary impact area spans approximately 15 acres with corrosive impacts to a depth of approximately six feet below land surface. The volume of contaminated soil within the primary impact area is estimated by the Army at 3,920,400 cubic feet.

Furthermore, the secondary impact area made up of either whole or fragments of DU penetrator rounds as a result of ricochets encompasses approximately 4,030 acres. The Army states that they expect to recover whole or fragments of DU penetrator rounds from the ground surface. However, in some cases, surficial soil (0-0.5 feet) may be necessary to remove due to corrosion products beneath recovered items.

The Army's cost estimate includes a 25 percent contingency factor that is applied to all decommissioning tasks. The Army's decommissioning cost estimate assumes that present-day institutional controls will be maintained until a technology becomes available to safely and cost-effectively address the explosive safety hazards related to UXO and DU in the DU Impact Area. In addition, any sale of the decontaminated land is prohibited due to the remaining explosive safety hazards of the UXO remaining throughout the DU Impact Area at JPG.

The financial assurance method for License No. SUB-1435 for JPG is currently an SOI, which the Army intends on maintaining under a "possession only" license. The Army's DFP states that they will evaluate and adjust the decommissioning cost estimates on a 3-year cycle to ensure costs accurately reflect changes in: material inventory and possession limits; contamination of applicable environmental media; facility modifications; remediation costs; and disposal costs. In addition, all revisions to cost estimates will include inflation. The Army will continue to update the estimates using RACER.

The Army DFP includes a signed SOI to request funds be made available, if a decision is made to engage in decommissioning activities, in the amount of $3.25 billion. The SOI is similar to the model language in NUREG-1757, Vol. 3, Rev. 1, Appendix A.11 "Statements of Intent". The SOI was signed by the Garrison Commander of the Army's Garrison-Rock Island Arsenal, including a letter, dated June 10, 2016, regarding his assumption of command. The Army notified the NRC by signed letter dated June 22, 2018, that a newly assigned Garrison Commander assumed duty June 20, 2018. However, the staff believe that the original SOI remains valid and finds that it is sufficient to cover the current decommissioning costs.

5.4 Evaluation Findings

5.4.1 Decommissioning Funding Plan

In the decommissioning cost estimate calculations, the Army includes costs for decommissioning and decontamination, reclamation of sites, structures, and equipment used in conjunction with site operation. The Army estimates the cost for decommissioning the site at $3.25 billion.

The NRC staff determined that: (1) the cost estimate does include the range of activities necessary to reclaim the individual sites (e.g., removal and remediation of contaminated soil and penetrator rounds and fragments); (2) that the Army based its cost estimate primarily on analyses performed using RACER; (3) that all phases and costs of decommissioning were included to meet the unrestricted release criteria; (4) the cost estimate included the volume of

contaminated soil needing remediation; (5) that the Army has provided adequate justification for the current decommissioning cost estimate for JPG; and (6) that the Army provided a description of its method of assuring funds through an SOI and adjusting cost estimates on a three-year basis to include inflation and facility modifications.

The NRC staff finds that the cost estimate is based on costs of a third-party contractor; does not take credit for salvage value; identifies key assumptions contained in the cost estimate; and includes an adequate contingency factor of 25 percent.

5.4.2 Statement of Intent

The Army is using an SOI to provide financial assurance for decommissioning pursuant to 10 CFR 40.36(e)(4). The NRC staff observed that the SOI includes language that indicates sufficient funds will be obtained when necessary for decommissioning. In addition, the SOI describes the qualifications of the issuer and presents a model SOI that is acceptable to the NRC per guidance in NUREG-1757, Vol. 3, Rev. 1, Appendix A.11, and "Statements of Intent". Therefore, the NRC staff finds that the SOI financial assurance instrument is acceptable.

5.5 Conclusions/Findings

Based on the information provided in the Army's license amendment request and the NRC staff's technical review of the DFP and SOI, the NRC staff concludes that the decommissioning cost estimate reasonably includes funds sufficient to cover the estimated costs of site decommissioning. In addition, the SOI is adequate to cover the decommissioning costs. The NRC staff finds that the Army DFP included with the license amendment request is acceptable and that the DFP and the SOI provide reasonable assurance that the estimate and financial assurance instrument will be adequate.

6.0 License Conditions

Under the possession-only approach, the Army will be required to maintain the license, site conditions, environmental monitoring, and security. The license institutional controls will include semi-annual surface water, sediment, and groundwater sampling. The Army will remain responsible for remediation of all DU contamination from the impact area north of the firing line. The staff finds that the requested license amendment is in accordance with the standards and requirements of the AEA, as well as NRC's rules and regulations.

The Army's approach to compliance with the regulatory requirements in Section 3.1 relied, in part, on groundwater monitoring. In the Army's response to NRC RAIs dated May 25, 2018, the Army proposed to add information regarding groundwater monitoring to the ERMP. A license condition is needed to ensure groundwater monitoring is performed because groundwater monitoring was used as part of the basis for compliance with the 10 CFR Part 20 Appendix B effluent limits and the 10 CFR Part 20 Subpart D public dose limits.

The Army's Standard Operating Procedure for environmental monitoring (Army, 2000) establishes an action level of 5.55 Bq/L (150 pCi/L) for total uranium in groundwater or surface water. However, that action level was not included in the language the Army proposed to add to the ERMP in the Army's response to NRC RAIs dated May 25, 2018. To address this issue, the

NRC staff proposes to add language regarding the action level as a new license condition 15 to specify the Army's environmental monitoring commitments. An additional license condition 14 was added to discuss the exemption from the decommissioning timeliness rule and a license condition 16 was added to address the maintenance of site conditions and fencing, and a MOA between all parties at JPG.

While License No.SUB-1435 allows the Army to replace the LRSO without prior approval of the NRC, best practice by the NRC identifies the LRSO on the license. To implement this practice, Amendment 20 will specifically identify the current LRSO on the license. In addition, based on conversations with the Army at the publicly noticed teleconference on September 16, 2019 (ADAMS Accession No. ML19261B626), a new condition 11D was added regarding the license certifying official for License No. SUB-1435.

No Form 313 will be required for a change in certifying official or a change in LRSO for License No. SUB-1435. The Army may communicate a change in certifying official via a letter that the NRC staff will add to the license docket. The Army may communicate a change in LRSO via a notification letter including the required training and experience documentation to support the LRSO change that the NRC staff would add to the license docket. On a notification of change in LRSO, the NRC staff will issue an administrative amendment to the license.

The existing license in effect September 24, 2018, (after Amendment 19 to SUB-1435) can be found at ADAMS Accession No. ML18192B084. In addition to the license conditions mentioned above, the following changes to the current license conditions are proposed, as requested by the Army (Army, 2016):

- Under Authorized Place of Use, to remove provision 10.B related to license transfer from Aberdeen Proving Ground to the Rock Island Arsenal – in that the transfer previously occurred and the information is already captured under Item 2 of the license.
- Under Conditions, to modify License Condition 12.D related to the JPG Security Plan – and note that it has been superseded by the current RSP, dated May 22, 2018 (ADAMS Accession No. ML18156A002). License Amendment 18, dated November 5, 2013 (ADAMS Accession No. ML13291A307), previously authorized the RSP to replace the JPG Security Plan, as documented in the Amendment 18 SER, ADAMS Accession No. ML13291A321).
- Under Conditions, to delete License Condition 13 related to submitting a decommissioning plan and environmental report by August 2013– the dates in this condition have already passed and the condition is no longer applicable.

Proposed License Conditions:

Revisions from the license conditions in amendment 19 due to license amendment request 20 are shown in bold and deletions are shown in strikethrough. These changes are shown as they would appear on Form 374, "Materials License" for Amendment No. 20, but without the bolding and strikethrough. The statements in brackets merely provide context for the changes and they will not appear on Form 374):

Sections 1 through 7: no changes

Section 8: Delete the words “No Limit”, as the limit of 80,000 kg appears directly below these words, creating a contradiction

9. Authorized Use: ~~For possession only for decommissioning. License renewal applications dated August 29, 1994.~~
For possession only. “Possession only” means residual radioactive material exists in place and administrative controls are maintained to minimize exposure to the public and the environment. [Staff determined that the additional qualification of the license better represents the intended Authorized Use]

10. Authorized place of use:

The licensed material shall be kept onsite for ~~the purpose of~~ **future** decommissioning in the restricted area known as the “Depleted Uranium Impact Area”. This area is located north of the firing line, at the Jefferson Proving Ground, in Madison, Indiana 47250.

~~B. This license has been transferred from the “U.S. Department of the Army, U.S. Army Soldier and Biological Chemical Command, Aberdeen Proving Ground, Maryland 21010-5424” to “U.S. Department of the Army, 1 Rock Island Arsenal, Rock Island, Illinois 61299-5000.”~~ [Staff determined that License item 10.B was no longer necessary as the license transfer previously occurred and is already captured in License Item 2.]

11. A. Licensed materials shall be kept under the supervision of the Radiation Safety Officer. **The Radiation Safety Officer for this license is Robert N. Cherry, Ph.D., U.S. Army Installation Management Command, IMSO Building 2261, 2450 Gun Shed Road, JBSA Fort Sam Houston, Texas 78234-1223.** [While the current license allows the licensee, without prior NRC approval, appoint an RSO, the staff determined best practice to identify the RSO explicitly in the license].

B. The licensee, without prior NRC approval, may appoint a RSO provided: a) the licensee maintains documentation demonstrating that the requirements of condition 11C are met; and b) the NRC is informed of the name of the new RSO within 30 days of the appointment by letter to Document Control Desk, Deputy Director, Division of Decommissioning, Uranium Recovery, and Waste Programs, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001.

C. The RSO shall have the following education, training, and experience: [This condition was moved from 11 A to 11 C]

1. Education: A Bachelor’s degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in radiological protection. Two years of relevant experience is generally considered equivalent to 1 year of academic study.

2. Health physics experience: At least 1 year of work experience in applied health physics, industrial hygiene, or similar work relevant to radiological hazards associated with site remediation. This experience should involve actually working with radiation detection and measurement equipment, not strictly administrative or “desk” work.

3. Specialized knowledge: A thorough knowledge of the proper application and use of all health physics equipment used for depleted uranium and its daughters, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to depleted uranium and its daughters, and a thorough understanding of how the depleted uranium was used at the location and how the hazards are generated and controlled.

D. The certifying official on this license is the garrison commander of Rock Island Arsenal. The U.S. Army shall notify the NRC within 30 days of any change in the name of the garrison commander by letter to Document Control Desk, Deputy Director, Division of Decommissioning, Uranium Recovery, and Waste Programs, Office of Nuclear Materials Safety and Safeguards, Mailstop T5A10, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001. [This is a new condition to allow the Army to notify the NRC of a change in certifying official without amending the license.]

12. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The NRC regulations shall govern unless the statements, representations, and procedures in the licensee’s application and correspondence are more restrictive than the regulation.

A. ~~Letter and attachments for license renewal dated August 29, 1994,~~ **Deleted** [The letter and attachments for license renewal dated August 29, 1994, have been superseded in their entirety]

B. ~~Letter dated May 25, 1995,~~ **Deleted** [Superseded]

C. ~~Application with attachments dated September 29, 1995, and~~ **Deleted** [Superseded]

D. ~~JPG Security Plan included with the letter dated December 10, 2003.~~ **Radiation Safety Plan dated May 22, 2018, that replaces the JPG Security Plan of December 10, 2003 (ML18156A002)** [As discussed in this SER, the JPG Security Plan has been superseded by the revised Radiation Safety Plan.]

E. ~~Request for change of licensing official and signed NRC Form 313 dated November 8, 2004~~. **Deleted** [Superseded]

F. ~~Request for change of licensing official and signed NRC Form 313 dated October 25, 2007.~~ **Deleted** [Superseded]

G. ~~Request for change of licensing official and signed NRC Form 313 dated February 4, 2008.~~ **Deleted** [Superseded]

H. ~~Request for change of licensing official and signed NRC Form 313 dated June 10, 2016~~. **Deleted**

I. ~~Request for change of licensing official and signed NRC Form 313 dated June 22, 2018~~ **Deleted** [This amendment will delete the tracking of all the Form 313 for changes in the certifying official, given the new condition 11 D that allows flexibility in notifying the NRC of the change in certifying official without amending the license]

J. Renewal application dated December 21, 2016 (ML17004A186), as amended by responses to NRC Requests for Additional Information dated May 25, 2018. (ML18156A002), including:

a. Environmental Radiation Monitoring Plan for the DU Impact Area at Jefferson Proving Ground, Indiana, dated December 21, 2016), as amended by responses to NRC Requests for Additional Information dated May 25, 2018. (ML18156A002)

13. ~~The Army shall submit a Decommissioning Plan for NRC review and approval under an alternate schedule identified in its May 25, 2005, Field Sampling Plan; its responses to action items from a September 8, 2005, public meeting by letter dated October 26, 2005; its Field Sampling Plan addendum dated November 2005 and all subsequent addendums; its responses to NRC's request for additional information by letter dated February 9, 2006; and its May 2, 2012 letter. The Army will also submit an Environmental Report using the guidance in NUREG-1748 for NRC to use in preparing an Environmental Impact Statement. The Decommissioning Plan and Environmental Report will be submitted no later than August 30, 2013.~~
Deleted. [By changing the license to "possession only," the DP and associated schedule are no longer applicable.]

14. The licensee is hereby granted an exemption from the NRC's decommissioning timeliness rule in 10 CFR 40.42(h)(1). This exemption is for a 20-year period. The U.S. Army must determine at that time if any technological developments have made decommissioning of the site feasible prior to requesting another exemption. One year prior to the end of the 20-year period, the U.S. Army must submit a timely license renewal application. [This is a new condition associated with the new "possession only," license.]

15. Groundwater and surface water samples will be collected semi-annually and analyzed for total/isotopic uranium using ASTM Method D3972-90M (alpha spectrometry). [This is a new condition associated with the U.S. Army groundwater monitoring commitments made in the responses to NRC Requests for Additional Information dated May 25, 2018. (ML18156A002)]

- **When analytical sampling results indicate that the U-238/U-234 activity ratio exceeds 3.0, the U.S. Army will notify NRC within 30 days. The U.S. Army will**

then reanalyze the samples using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and calculate the weight percentage of U-235 to determine if the sample results are indicative of totally natural uranium (at or about 0.711 weight percent U-235) or DU mixed with natural uranium (obviously less than 0.711 weight percent U-235). The U.S. Army will notify NRC of these ICP-MS results within 30 days of the reanalysis. The notification will be by letter to the Document Control Desk, Deputy Director, Division of Decommissioning, Uranium Recovery, and Waste Programs, Office of Nuclear Materials Safety and Safeguards, Mailstop T5A10, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001.

- **When analytical sampling results indicate that the total concentration of uranium exceeds 5.5 Bq/L (150 pCi/L), the U.S. Army will notify NRC within 30 days and collect additional samples within 30 days of the notification to NRC, unless prohibited by the absence of the sampling media. The U.S. Army will notify NRC of these additional sample results within 30 days of the reanalysis. All notifications will be by letter to the address in condition 15A.**

16. Maintenance of the site conditions, fencing, postings, and security are the responsibility of the U.S. Army. However, U.S. Fish and Wildlife Service and the U.S. Air Force may meet these requirements on behalf of the U.S. Army in accordance with current Memorandums of Agreement (MOA), which the U.S. Army will provide to the NRC.

7.0 Acronyms and Initialisms

ADAMS	Agency Document Access and Management System
AEA	Atomic Energy Act of 1954, as amended
ALARA	As Low As is Reasonably Achievable
ANL	Argonne National Laboratory
CFR	*Code of Federal Regulations*
DFP	Decommissioning Funding Plan
DP	Decommissioning Plan
DOE	U.S. Department of Energy
DU	Depleted Uranium
ER	Environmental Report
ERMP	Environmental Radiation Monitoring Plan
FR	*Federal Register*
FWS	U.S. Fish and Wildlife Service
IMCOM	U.S. Army Installation Management Command
INANG	Indiana Army National Guard
JPG	Jefferson Proving Ground
NRC	Nuclear Regulatory Commission
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
PCZ	Primary Contamination Zone
RACER	Remedial Action Cost Engineering and Requirements
RAI	Request for Additional Information
RESRAD	dose assessment code for RESidual RADioactive materials
RSO	Radiation Safety Officer
RSP	Radiation Safety Plan
SCZ	Secondary Contaminated Zone
SER	Safety Evaluation Report
SOI	Statement of Intent
SOP	Standard Operating Procedures
TEDE	Total Effective Dose Equivalent
UXO	Unexploded ordinance

8.0 References

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