
Technical Evaluation Report

**For the U.S. Department of Energy UMTRCA Title I
Moab, Utah, Former Processing Site:
Supplemental Standards for U.S. Highway 191 and Historical Highway Rights-of-Way**

**U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001**



January 2019

**Technical Evaluation Report
for
Application of Supplemental Standards
for Historical Highway and U.S. Highway 191 Rights-of-Way
at the Moab Uranium Mill Tailings Remedial Action Project Site:**

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FACILITY: Moab Uranium Mill Tailings Remedial Action Project Site

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1.0 SUMMARY

The U.S. Department of Energy (DOE) has requested U.S. Nuclear Regulatory Commission (NRC) concurrence on the application of supplemental standards for (1) the historical highway that underlies the portion of the North Moab Canyon Recreation Trail and (2) U.S. Highway 191 rights-of-way for the Moab Uranium Mill Tailings Remedial Action Project site. Per the criteria in 40 CFR 192.22, DOE is permitted to apply supplemental standards in lieu of the cleanup standards in generic or individual situations that meet the eligibility requirements of 40 CFR 192.21. The NRC staff has reviewed DOE's application of supplemental standards for these two areas using the guidance in "Final Standard Review Plan for the Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act," Revision 1 (NRC, 1993). Based on the NRC staff's detailed review of the applications, the staff has determined that the dose assessments are adequate to confirm that the residual radioactive materials would not be expected to pose significant present or future health risks to likely receptors.

2.0 INTRODUCTION

2.1 BACKGROUND

DOE's Moab Uranium Mill Tailings Remedial Action Project Site, located in Moab, Utah, is the site of a former uranium mill that was constructed in 1956 by the Uranium Reduction Company. In 1962, Atlas Minerals Corporation (Atlas) acquired the site and sold uranium concentrates to the U.S. Atomic Energy Commission for use in national defense programs until 1970. After 1970, Atlas primarily sold uranium concentrates for commercial uses in nuclear power plants. Atlas operated the site until 1984 under the licensing and regulatory authority of the NRC.

Public concern about potential human health and environmental effects from uranium mill tailings led the U.S. Congress to pass the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 (Public Law 95–604), which required the cleanup of inactive uranium-ore processing sites. Because the Moab mill was active and commercially owned when the law was passed in 1978, its cleanup was initially regulated under an NRC license per the UMTRCA, Title II.

Atlas demolished the processing buildings and buried them in the southwestern corner of the tailings pile and placed an interim cover over the pile as part of decommissioning activities conducted between 1988 and 1995. Atlas proposed stabilizing the tailings pile at Moab by permanently capping it in place; however, Atlas declared bankruptcy in 1998 prior to completing its planned decommissioning activities. The NRC, working with the State of Utah, appointed PricewaterhouseCoopers as the trustee of the Moab Mill Reclamation Trust and licensee for the site. The trustee initiated site reclamation, conducted groundwater studies, and performed site maintenance activities.

With the enactment of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (Public Law 106–398), Congress included the Moab site under Title I of UMTRCA. The act stipulated that the license issued by the NRC for the Moab site materials be terminated and that title to the property and responsibility for cleanup be transferred to DOE. In October 2001, DOE assumed ownership of the Moab site.

The Moab site is considered a processing site under Title I of UMTRCA and, as such, DOE is responsible for remediating the site in a safe and environmentally sound manner in accordance with the remedial action plan (DOE, 2008) prepared pursuant to section 3405(i) of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (10 USC 7420 note; Public Law 105-261), including groundwater restoration; and the removal, to a site in the State of Utah, for permanent disposition and any necessary stabilization, of residual radioactive material and other contaminated material from the Moab site and the floodplain of the Colorado River.

Per Section 108 of UMTRCA, the Moab Uranium Mill Tailings Remedial Action Project Site in Moab, Utah, is being cleaned up to U.S. Environmental Protection Agency (EPA) standards per Title 40 of the *Code of Federal Regulations* (40 CFR), Part 192, “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings,” and with concurrence of the NRC. DOE prepared a remedial action plan (DOE, 2008) and received conditional concurrence from the NRC July 2008 (NRC, 2008), with final concurrence pending adequate cleanup of groundwater.

In its remedial action plan, DOE committed to remediate contaminated soils to meet the EPA radium-226 standards in 40 CFR 192 (i.e., 5 picocuries per gram (pCi/g) [185 millibecquerels per gram (mBq/g)] on the surface and 15 pCi/g [555 mBq/g] in the subsurface) and to place the contaminated soils in an engineered disposal cell. Where remediation of contaminated soils would not be practical or feasible, DOE indicated it would consider applying supplemental standards according to 40 CFR 192.21. DOE stated that supplemental standards would be

applied in areas where excessive environmental harm or worker risk outweighed the benefits of attaining the EPA soil cleanup standards. DOE indicated that several potential uses of supplemental standards would be applied in certain areas, including those areas under asphalt on state and federal highways. DOE stated that the proposed supplemental standards must be concurred by the NRC.

2.2 SUPPLEMENTAL STANDARDS APPLICATIONS

On November 21, 2016 (DOE, 2016), DOE requested the NRC's concurrence on the application of supplemental standards for the historical highway in the Utah Department of Transportation (UDOT) right-of-way that underlies the portion of the North Moab Canyon Recreation Trail on the site. DOE is proposing a no-remediation alternative and application of supplemental standards using 40 CFR 192.21(b) as the justification because remedial actions would, notwithstanding reasonable measures to limit damage, directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future.

On July 31, 2017 (DOE, 2017), DOE requested the NRC's concurrence on the application of supplemental standards for U.S. Highway 191 rights-of-way that lie within the UDOT rights-of-way on the site. DOE is proposing no remediation for this area and application of supplemental standards using 40 CFR 192.21(c) as the justification because he estimated cost of remedial action is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard.

2.3 SCOPE OF THE REVIEW

This technical evaluation report documents the NRC staff's findings from its review of DOE's application of supplemental standards for both the historical highway right-of-way and U.S. Highway 191 rights-of-way within DOE's Moab site boundary. The NRC staff reviewed DOE's requests for concurrence with application of supplemental standards for the rights-of-way using guidance in Section 5.0 of "Final Standard Review Plan for the Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act," Revision 1 (NRC, 1993; hereafter, the Standard Review Plan).

3.0 TECHNICAL EVALUATION

The remedial action at the Moab site must meet cleanup standards for residual radioactive material. To evaluate DOE's approach for applying supplemental standards for the historical highway and U.S. Highway 191 rights-of-way, the NRC staff, in accordance with Section 5.1.2 of the Standard Review Plan, reviewed the data defining the cleanup standards to be used at the Moab site, the extent of contamination, and the methods used to verify that the standards have been met.

3.1 CLEANUP STANDARDS

Per Section 5.2.2 of the Standard Review Plan, the acceptance criteria pertinent to the radiological aspects of DOE's request are provided in 40 CFR 192, Subpart B. The criteria at

40 CFR 192.12 requires that the concentration of radium-226 in land averaged over any area of 100 square meters [m²] shall not exceed the background level by more than:

- 5 pCi/g [185 mBq/g], averaged over the first 15 cm of soil below the surface and
- 15 pCi/g [555 mBq/g], averaged over 15-cm thick layers of soil more than 15 cm below the surface.

Per the criteria in 40 CFR 192.22, DOE is permitted to apply supplemental standards in lieu of the cleanup standards in generic or individual situations that meet the eligibility requirements of 40 CFR 192.21. Supplemental standards may be applied if the remedial action would cause any of these circumstances to exist:

- (a) A clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.
- (b) Notwithstanding reasonable measures to limit damage, directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future. A clear excess of health and environmental harm is harm that is long-term, manifest, and grossly disproportionate to health and environmental benefits that may reasonably be anticipated.
- (c) The estimated cost of remedial action at a “vicinity” site (described under Section 101(6)(B) of UMTRCA) is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under 40 CFR 192.12(a) (i.e., standards for concentration of radium-226 in soils).
- (d) The cost of a remedial action for cleanup of a building is clearly unreasonably high relative to the benefits. Factors that should be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by the remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.
- (e) There is no known remedial action.

- (f) The restoration of groundwater quality at any designated processing site is technically impracticable from an engineering perspective.
- (g) The groundwater meets the criteria of 40 CFR 192.11(e), which is the definition of a limited-use groundwater.
- (h) Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

When one or more of the criteria of 40 CFR 192.21(a) through (g) applies, DOE is required by 40 CFR 192.22(a) to select and perform the alternative remedial action that comes as close to meeting the otherwise applicable cleanup standard as is reasonably achievable. When DOE proposes remedial actions for a specific location, 40 CFR 192.22(c) requires DOE to inform any private owners and occupants of the affected location, solicit their comments, and provide those comments to the other implementing agencies (e.g., the NRC).

3.1.1 NRC STAFF REVIEW AND ANALYSIS

3.1.1.1 HISTORICAL HIGHWAY RIGHT-OF-WAY

For the historical highway right-of-way, DOE is proposing to apply supplemental standards using 40 CFR 192.21(b), excessive environmental harm relative to the health benefits. The NRC staff reviewed DOE's request for supplemental standards for the historical highway right-of-way to determine if DOE provided adequate information to justify the use of the criterion at 40 CFR 192.21(b). The NRC staff's review focused on the site characterization data and the dose assessment used for verification. For more detail on the NRC staff's review for the historical highway right-of-way for both DOE's site characterization data and dose assessment, see Sections 2.2.1.1 and 2.3.1.1 of this technical evaluation report, respectively.

To justify applying supplemental standards because of excessive environmental harm relative to long-term benefits, DOE determined, based on the results of a dose assessment, that the proposed supplemental standards area would not pose a significant present or future health risk to the public due to the very low exposure levels and limited exposure time. The dose assessment evaluated exposures to likely users of the North Moab Canyon Recreational Trail atop the historical highway right-of-way. DOE indicated that remediation of this area to meet the criteria at 40 CFR 192.12 would pose an unacceptable harm to the environment compared to the health and environmental benefits of remediation due to the disturbance of the historical highway right-of-way and overlying North Moab Canyon Recreation Trail. DOE estimated that remediating the supplemental standards area would require removal of approximately 2,000 cubic yards [1,529 cubic meters] of soil containing residual radioactive material above the 40 CFR 192.12 criteria and cause disturbance of the natural environment along the North Moab Canyon Recreation Trail, which connects the town of Moab to Arches National Park. Given the dose assessment estimates doses to likely users of the North Moab Canyon Recreational Trail

are very low (less than 3 millirem per year (mrem/year)), the NRC staff agrees that the environmental harm from disturbance of the trail would be excessive relative to the health benefits.

3.1.1.2 U.S. HIGHWAY 191 RIGHTS-OF-WAY

DOE is proposing application of supplemental standards using 40 CFR 192.21(c), remedial costs are clearly excessive compared to the long-term benefit and the residual radioactive materials do not pose a clear present or future hazard. The NRC staff reviewed DOE's request for U.S. Highway 191 rights-of-way to determine whether DOE provided adequate data to determine that the criterion at 40 CFR 192.21(c) appropriately applies. The NRC staff's review focused on the site characterization data and the dose assessment used for verification. For more detail on the NRC staff's review for the historical highway right-of-way of the both DOE's site characterization data and dose assessment, see Sections 2.2.1.2 and 2.3.1.2 of this technical evaluation report, respectively.

To justify that applying supplemental standards is appropriate, DOE determined, based on the results of a dose assessment, which evaluated the exposures to highway maintenance crews, that the proposed supplemental standards area would not pose a significant present or future health risk and remediation of the area would be costly compared to the health and environmental benefits. DOE estimated that remediating the supplemental standards area would require removal of approximately 2,065 cubic yards [1,579 cubic meters] of soil containing residual radioactive material above the 40 CFR 192.12 criteria. Given the dose assessment estimates doses to users of U.S. Highway 191 are very low (less than 25 mrem/year, in most cases), the NRC staff agrees that the cost to remove the soil contaminated with residual radioactive materials from the rights-of-way would be excessive relative to the health benefits.

3.1.2 EVALUATION FINDINGS

Based on its detailed review of both of DOE's requests for NRC concurrence to apply supplemental standards and references supporting DOE's requests, the NRC staff has determined that the DOE has provided adequate justification, based on the estimated risks, that additional remediation would cause excessive environmental harm compared to the benefits for the historical highway right-of-way or result in excessive cost for the U.S. Highway 191 rights-of-way. The NRC staff has reviewed DOE's site characterization data and dose assessments and determined that they are adequate to confirm that the residual radioactive materials would not be expected to pose significant present or future health risks to likely receptors (see Section 2.3 of this technical evaluation report).

3.2 SITE CHARACTERIZATION

Per Section 5.3.2.2 of the Standard Review Plan, DOE must provide adequate data for the NRC to determine that one or more of the criteria of 40 CFR 192.21 appropriately applies to the area(s) in question, including data from radiological characterization to identify the depth and areal extent of residual radioactive materials.

3.2.1 NRC STAFF REVIEW AND ANALYSIS

3.2.1.1 HISTORICAL HIGHWAY RIGHT-OF-WAY

The specific area to which DOE intends to apply supplemental standards is a 107,000-square-foot (ft²) [9,940-m²] area that includes a portion of the UDOT historical highway right-of-way and inaccessible areas that lie within DOE's Moab site just south of the northern property boundary. Much of the area is covered with asphalt pavement. Some asphalt dates to the 1950s or before as part of the former state highway. In 2010, the former highway, including the portion associated with this supplemental standards area, was converted to the North Moab Canyon Recreation Trail, which is maintained by Grand County, Utah.

DOE suspects that residual radioactivity in the supplemental standards area is either windblown tailings from the former mill site or pieces of ore lost during transport on the historical highway. DOE remediated contaminated soils within the historical highway right-of-way, but outside this supplemental standard area in 2006 (DOE, 2007b).

DOE conducted site characterization of the historical highway right-of-way in 2005 and 2016. In 2005, DOE collected soils from the historical right-of-way and recorded results of laboratory analyses in "Radiological Assessment for Non-Pile Areas of the Moab Project Site" (DOE, 2005). In 2016, DOE obtained direct gamma exposure-rate measurements which are detailed in Appendix A of DOE's request for application of supplemental standards (DOE, 2016).

The NRC staff reviewed the application to determine whether DOE performed adequate radiological characterization of the residual radioactive materials to justify that the criterion at 40 CFR 192.21(b) appropriately applies. The NRC staff reviewed the adequacy of the data DOE used to develop background concentrations and the areal extent and depth of the residual radioactive material in the proposed supplemental standards area for the historical highway right-of-way.

3.2.1.2 U.S. HIGHWAY 191 RIGHTS-OF-WAY

The specific area to which DOE intends to apply supplemental standards is a 62,900-ft² [5,840-m²] area that encompasses portions of the northern and southern edges of U.S. Highway 191 rights-of-way that lie within the Moab site property boundary, including a drainage culvert that crosses beneath the highway.

DOE suspects that residual radioactivity in the supplemental standards area is either windblown tailings from the former mill site or pieces of ore lost during transport on the highway. DOE remediated contaminated soils within the U.S. Highway 191 rights-of-way, but outside this supplemental standard area in two phases in 2003 and 2006 (DOE, 2007a-b). Contaminated soils within this supplemental standards area were left in place as part of a 1:1 slope to ensure stability and safety of the highway.

DOE conducted site characterization of the U.S. Highway rights-of-way from 2001 through 2005. DOE documented the results of its site characterization in “Radiological Assessment for Non-Pile Areas of the Moab Project Site” (DOE, 2005).

The NRC staff reviewed DOE’s request to determine whether DOE performed adequate radiological characterization of the residual radioactive materials to justify that the criterion at 40 CFR 192.21(c) appropriately applies. The NRC staff reviewed the adequacy of the data DOE used to develop background concentrations and the areal extent and depth of the residual radioactive material in the proposed supplemental standards area for the U.S. Highway 191 rights-of-way.

3.2.2 EVALUATION FINDINGS

Based on its detailed review of DOE’s requests for concurrence on applications of supplemental standards and supporting references, the NRC staff has determined that DOE has adequately characterized the historical and U.S. Highway 191 rights-of-way to identify the depth and areal extent of the residual radioactive materials for NRC to determine that one or more of the criteria of 40 CFR 192.21 appropriately applies to the areas in question.

3.3 VERIFICATION PROCEDURES

Since supplemental standards are being proposed, DOE needs to demonstrate that health risks associated with leaving the residual radioactive material in place, in lieu of remediation, are not significant and remediation would cause excessive environmental harm or cost relative to the health risk mitigated by remediation of the residual radioactive material. To do this, DOE evaluated the impacts of remedial action via a dose assessment based on the data from site characterization. The NRC staff evaluated DOE’s dose assessment methodology and results using guidance in NUREG-1757, Volume 2, Revision 1, “Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria,” (NRC, 2006) for evaluating site-specific dose assessments. Specifically, the NRC staff used the guidance in Section 5 and Appendix I of NUREG-1757, Volume 2, Revision 1.

The dose modeling is acceptable if it is sufficient to demonstrate the possible future impacts from the residual radioactive material. The assessment can be either realistic or prudently conservative. The information should allow an independent NRC staff evaluation of the assumptions used (e.g., source term configuration, applicable transport pathways) and possible doses to the average member of the critical group. The dose assessment is acceptable provided that NRC staff has reasonable assurance that DOE has adequately characterized and applied the source term, has analyzed the appropriate scenario(s) and represented the critical group with the selected exposure group(s), and has appropriately applied the mathematical method and parameters for the scenario and addressed parameter uncertainty adequately.

3.3.1 NRC STAFF REVIEW AND ANALYSIS

3.3.1.1 HISTORICAL HIGHWAY RIGHT-OF-WAY

Exposure Scenario(s) and Critical Group(s)

DOE documented its evaluation of scenarios in Section 1 of Appendix A of its application for supplemental standards for the historical highway (DOE, 2016). DOE determined an adult walking along the North Moab Recreation Trail was the most likely user, or average member of the critical group. DOE considered direct gamma (external) exposure, inhalation of radionuclides in dust, and ingestion of radionuclides in dust. Exposure pathways explicitly not considered in their assessment included inhalation of radon, consumption of vegetation, and ingestion of water from sources in the supplemental standards area. Outdoor air typically contains very low levels of radon and the radon limit in DOE Order 458.1 is for indoor air. The other two pathways were not considered because of a lack of edible vegetation and water sources in the area, respectively.

Source Term

DOE evaluated the doses resulting from residual radioactive material that will remain within the supplemental standards area. For external exposures, DOE evaluated the average gamma exposure rate observed at 3.3 feet (1 meter) during gamma scans along the North Moab Recreation Trail. In Table 1 (Appendix A of DOE's historical highway application (DOE, 2016)), DOE lists the observed gamma exposure rates observed in the verification block (see Plate 1 of DOE, 2016). DOE calculated the average of the observed gamma exposure rates at 12 microrem per hour ($\mu\text{rem/hr}$) [120 microsieverts per hour ($\mu\text{Sv/hr}$)]. For internal exposures, DOE averaged Ra-226 concentrations observed in soil samples collected during the assessment of non-pile areas of the Moab site in 2005. In Table 4 (Appendix A of DOE historical highway application (DOE, 2016)), DOE presents the Ra-226 concentrations in the upper 6 inches [15 centimeters] of soil at each sample location within the proposed supplemental standards area. DOE calculated the average Ra-226 concentration observed in the soil samples was 12.96 pCi/g [0.4795 Bq/g].

Dose Calculations

DOE documented its calculations for each exposure pathway evaluated in Section 2.0 of Appendix A of its historical highway application (DOE, 2016).

External Exposures

For external exposures, DOE calculated doses using the average external exposure rate from gamma scans of the verification block summarized earlier (i.e., 12 $\mu\text{rem/hr}$ [120 $\mu\text{Sv/hr}$]) and an exposure time of 78 hours per year. To determine the exposure time, DOE assumed that a trail walker walks at a pace of 2 miles per hour (3 kilometers per hour) for 3,300 feet (ft) [1 kilometer (km)] of trail in the proposed supplemental standards area 5 days per week, 50 weeks per year. DOE noted that the length of trail within the supplemental standards area is 2,700 ft [0.82 km]. DOE estimated the resultant annual external dose received by the walker at 0.94 (mrem) [9.4 μSv]. Because it is plausible that a trail walker may traverse both directions on any given day, the NRC staff independently evaluated the external doses from a trail walker traversing the

2,700-ft [0.82-km] trail in both directions, once per day, 5 days per week, 50 weeks per year. The resultant annual external doses for the walker are estimated at 1.5 mrem [15 μ Sv].

Inhalation Exposures

For doses resulting from inhalation of dust, DOE used an enhancement factor to estimate the concentration of radium in dust, based on an average of observed concentrations in the upper 6 inches (15 centimeters) of soil, breathed by the trail walker traversing the trail in the proposed supplemental standards area. DOE based the enhancement factor on loam soil and the ambient dust concentration in the calculation from the 98th percentile of values of atmospheric particulate matter with a diameter less than 2.5 micrometers that were sampled by the Utah Department of Environmental Quality (UDEQ) at its reporting station near Hurricane, Utah, which is approximately 225 miles [362 kilometers] to the southwest of DOE's Moab site. DOE also based the trail walker's inhalation rate on the EPA's Exposure Factors Handbook for an average adult performing light work (see Table 6-28; EPA, 2011). DOE applied inhalation dose conversion factors for adults, presented in Table 5, Appendix A of its historical highway application (DOE, 2016), from the International Commission on Radiological Protection (ICRP). DOE estimated the resultant annual inhalation dose received by the walker at 0.0022 mrem [0.022 μ Sv].

The NRC staff independently evaluated an inhalation dose to confirm DOE's results and evaluate uncertainty in input parameters. The NRC staff used default parameters for dust loading in air and inhalation rates described in NUREG-5512, Volume 3 (NRC, 1999) and the ICRP inhalation dose conversion factors used by DOE. The NRC staff evaluated alternative dust loading and inhalation rates because DOE relied on dust loading from a distant reporting station that also reports 98th-percentile PM_{2.5} particulate concentrations consistently less than every other reporting station in the State of Utah. Specifically, the NRC staff assumed a breathing rate of 1.4 cubic meters per hour, which is more than double the value used by DOE, and a particulate concentration of 1×10^{-4} grams per cubic meter, which is an order of magnitude larger than the value used by DOE and larger than the 98th percentile of observed PM_{2.5} concentrations at all Utah measurement stations since the year 2000 (UDEQ, 2018). As described earlier for the external exposure evaluation, the NRC staff also assumed the trail walker spends twice DOE's assumed exposure time in the proposed supplemental standards area. Based on these assumptions, the NRC staff independently estimated an annual inhalation dose of 0.09 mrem [0.9 μ Sv].

Ingestion Exposures

For doses resulting from ingestion of dust, DOE used a similar mathematical approach to that it used for inhalation of dust, substituting an ingestion rate in the ingestion dose calculations for the product of the inhalation rate and concentration of dust in air described earlier in the inhalation dose calculations. DOE assumed a dust ingestion rate of 0.1 gram per day. DOE applied ingestion dose conversion factors for adults, presented in Table 5, Appendix A, of its historical highway application (DOE, 2016), from the ICRP. DOE estimated the resultant annual ingestion dose received by the walker at 0.018 mrem [0.18 μ Sv].

The NRC staff independently evaluated the dose from ingestion of dust to confirm DOE's results and evaluate uncertainty in input parameters. The NRC staff used the default soil ingestion parameter for a residential gardener described in NUREG/CR-5512, Volume 3 (NRC, 1999), and the and the ICRP ingestion dose conversion factors used by DOE to evaluate uncertainty in the soil ingestion parameter. DOE's dust ingestion rate is equal to the maximum dust ingestion rate in the default distribution described in NUREG/CR-5512, Volume 3, and is reasonably conservative. As described earlier for the external exposure evaluation, the NRC staff assumed the trail walker spends twice DOE's assumed exposure time in the proposed supplemental standards area. Based on these assumptions, the NRC staff independently estimated an annual ingestion dose of 0.036 mrem [0.36 μ Sv].

Total Exposures

DOE reports in Table 6 of its historical highway application (DOE, 2016), a total estimated dose for a trail walker of 0.96 mrem [9.6 μ Sv]. The NRC staff also performed independent analyses using the RESRAD-ONSITE code, Version 7.2, with: (i) default parameters, except those identified specifically in the NRC's independent pathways analyses above; (ii) soil concentrations of all radionuclides that were identified in DOE's calculations and are available in RESRAD-ONSITE equal to the concentration of radium-226 (i.e., those radionuclides are in equilibrium with radium-226); and (iii) radon exposures enabled in RESRAD-ONSITE. The NRC staff estimated a total annual dose of less than 3 mrem [30 μ Sv] for the proposed supplemental standards area in this analysis. Based on the NRC staff's review of DOE's analysis, its independent analysis, and its RESRAD-ONSITE calculations with certain parameters changed as described earlier to evaluate uncertainty, the NRC staff estimates that using reasonably conservative input parameters a total estimate of annual dose is unlikely to exceed few millirem [few tens of microsieverts] for a trail walker.

3.3.1.2 U.S. HIGHWAY 191 RIGHTS-OF-WAY

Exposure Scenario(s) and Critical Group(s)

Because the supplemental standards area is within public highway rights-of-way, DOE determined the most reasonable scenario for exposure to a member of the public is a highway maintenance worker. DOE considered both a worker repairing the highway at the point of highest surface soil Ra-226 activity concentration and a worker performing general maintenance on the entire road as it traverses the supplemental standards areas. Because DOE has observed tractor-trailers parked in pull-off areas adjacent to the highway for extended periods, presumably so the driver can nap in the tractor sleeper, DOE also evaluated doses to a truck driver.

The exposure pathways that DOE considered reasonable for all of the aforementioned critical groups include direct gamma (external) radiation, inhalation of radionuclides in dust, and inhalation of radon and its decay products. In addition, for the highway worker scenarios, DOE considered incidental ingestion of radionuclides in soil. DOE excluded water dependent pathways and food ingestion pathways from the analysis since no groundwater wells would be

established in the supplemental standards area, and no food would be raised in the area. All exposures were assumed outdoors because no structures are expected to be built upon the highway rights-of-way.

Source Term

DOE evaluated the doses resulting from residual radioactive material that will remain within the proposed supplemental standards area. For the various scenarios evaluated, DOE used two different source terms derived from radiological measurements taken within the proposed supplemental standards area: (1) the maximum concentration observed during the surface (i.e., 6 inches [15 centimeters] in depth or less) and subsurface (6 inches [15 centimeters] in depth) assessment from 2001 to 2005 for both the worker repairing a small section of the highway and the resting truck driver scenarios; and (2) the overall average concentration of both the measurements from the surface and subsurface assessment as well as excavation controls samples collected from the surface of the general area of the proposed supplemental standards area during remediation for the scenario evaluating a worker performing general maintenance on the entire road as it traverses the proposed supplemental standards area. Table A-4 of its Highway 191 application (DOE, 2017) lists the concentrations assumed for each scenario.

To determine the overall average concentration, DOE first determined an average of the maximum measurements observed at each location from the surface and subsurface assessment. Table A-2 of its Highway 191 application (DOE, 2017) lists the concentrations observed in the verification block (see Plate 1 of DOE, 2017) during the assessment. Next, DOE determined an average of the measurements from the excavation control samples collected during remediation. Table A-3 of its Highway 191 application (DOE, 2017) lists the concentrations observed from the collection of excavation control samples during remediation. Finally, DOE calculated the overall average concentration from the two aforementioned average concentrations.

DOE assumed that all radionuclides from the uranium-238 decay series were in equilibrium; that is, present at the same activity concentration as Ra-226. This is a reasonable assumption if the contamination is entirely due to ore. Because the contamination also includes uranium mill tailings, which are somewhat depleted in uranium isotopes, the equilibrium assumption based on the Ra-226 concentration is likely conservative.

Dose Calculations

DOE documents its calculations for each exposure pathway evaluated in Section 2.0 of Appendix A of its Highway 191 application (DOE, 2017). DOE used the RESRAD code to calculate doses for each scenario and exposure pathway evaluated. DOE lists the values of input parameters used in the scenarios analyses in Table A-1 of its Highway 191 application (DOE, 2017). The results of DOE's analyses are documented in Table A-5 of its Highway 191 application (DOE, 2017). All estimated doses, though for some scenarios greater than a few millirem [tens of microsieverts], were below 25 mrem/yr [250 μ Sv/yr], which is a dose consistent with the NRC's unrestricted release criteria in 10 CFR 20.1402, "Radiological criteria for

unrestricted use” for decommissioning licensees. The NRC staff notes that there appears to be an error in the computation of annual breathing rate for the resting truck driver. Converting 0.43 cubic meters per hour to an annual breathing rate results in 3,770 cubic meters per year rather than the value reported by DOE (i.e., 3,740 cubic meters per year) in Table A-1 of its Highway 191 application (DOE, 2017).

The NRC staff performed independent calculations using RESRAD-ONSITE, Version 7.2, to confirm DOE’s results and evaluate uncertainty in input parameters. The NRC staff conducted sensitivity analyses on input parameters pertinent to the calculations for relevant pathways. For the scenario evaluating doses to a highway worker repairing a small section of the U.S. Highway 191 rights-of-way, the NRC staff varied the soil concentration of radionuclides (up to 107.6 pCi/g [3.981 Bq/g], which was the highest observed concentration, whether surface or subsurface) and the occupancy time (doubled). For the scenario evaluating doses to a general maintenance highway worker, the NRC staff varied the soil concentration of radionuclides (up to 29.1 pCi/g [1.08 Bq/g], which is the average of all measurements reported by DOE, both surface and subsurface) and the occupancy time (doubled). Other parameters were not varied because they were equivalent to or more conservative than default screening parameters used for decommissioning that are reported in NUREG/CR-5512, Vol. 3 (NRC, 1999). For the scenario evaluating doses to a resting truck driver, the NRC staff varied the soil concentration of radionuclides (up to 107.6 pCi/g [3.981 Bq/g], which was the highest observed concentration, whether surface or subsurface). The results of these independent analyses indicate in all cases except one, that the conservatively estimated annual doses would remain below 25 mrem [250 μ Sv]. The one exception was the resting truck driver results. The NRC staff estimated an annual dose of 36 mrem [360 μ Sv] when the maximum subsurface soil concentration was evaluated. However, the staff expect that this result is very conservative because the observed concentration is currently shielded by more than 6” of soil and the resting driver would be elevated above the ground, thereby increasing the distance from the source than assumed in RESRAD-ONSITE.

3.3.2 EVALUATION FINDINGS

Based on its detailed review of DOE’s requests for concurrence on applications of supplemental standards and supporting references, the NRC staff has determined that DOE’s dose assessment is sufficient to determine the possible future impacts from the residual radioactive material. The NRC staff has reasonable assurance that DOE has adequately characterized and applied the source term, has analyzed the appropriate scenario(s) and that the exposure group(s), has adequately represented a critical group, and has appropriately applied the mathematical method and parameters for the scenario and parameter uncertainty has been adequately addressed. Therefore, the NRC staff finds DOE’s use of a dose assessment is acceptable as verification in applying supplemental standards in lieu of remediation because the residual radioactive material is not significant.

4.0 CONCLUSION

The NRC staff reviewed DOE’s application of supplemental standards for the historical highway and U.S. Highway 191 rights-of-way using the guidance in “Final Standard Review Plan for the

Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act,” Revision 1 (NRC, 1993). Based on the NRC staff’s detailed review of the applications, the staff determined that the dose assessments are adequate to confirm that the residual radioactive materials would not be expected to pose significant present or future health risks to likely receptors. Further, the NRC staff, based on its review, has determined that DOE has provided adequate justification, based on the estimated risks, that additional remediation would cause excessive environmental harm compared to the benefits for the historical highway right-of-way or result in excessive cost for the U.S. Highway 191 rights-of-way.

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