

DOE/EIS-0269

**FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT
AND USE OF DEPLETED URANIUM HEXAFLUORIDE**

Summary

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U.S. Department of Energy
Office of Nuclear Energy, Science and Technology

**APPENDIX I:
ENVIRONMENTAL IMPACTS OF OPTIONS
FOR DISPOSAL OF OXIDE**

TABLE I.2 Summary of Disposal Option Impacts for U₃O₈ during the Operational Phase^a

A. Grouted

Impacts from Disposal as Grouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Grouted U ₃ O ₈ in Vaults	Impacts from Disposal as Grouted U ₃ O ₈ in a Mine
<i>Human Health – Normal Operations: Radiological</i>		
Involved Workers:	Involved Workers:	Involved Workers:
Total collective dose: 480 person-rem	Total collective dose: 520 person-rem	Total collective dose: 720 person-rem
Total number of LCFs: 0.2 LCF	Total number of LCFs: 0.2 LCF	Total number of LCFs: 0.3 LCF
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
Annual dose to MEI: 0.0021 – 0.0088 mrem/yr	Annual dose to MEI: 0.0021 – 0.0088 mrem/yr	Annual dose to MEI: 0.00084 – 0.0085 mrem/yr
Annual cancer risk to MEI: 8×10^{-10} – 4×10^{-9} per year	Annual cancer risk to MEI: 8×10^{-10} – 4×10^{-9} per year	Annual cancer risk to MEI: 3×10^{-10} – 3×10^{-9} per year
Total collective dose: 0.00054 – 0.0035 person-rem	Total collective dose: 0.00059 – 0.0038 person-rem	Total collective dose: 0.00057 – 0.0036 person-rem
Total number of LCFs: 2×10^{-7} – 1×10^{-6} LCF	Total number of LCFs: 2×10^{-7} – 2×10^{-6} LCF	Total number of LCFs: 2×10^{-7} – 1×10^{-6} LCF
General Public:	General Public:	General Public:
Annual dose to MEI: 0.0061 – 0.026 mrem/yr	Annual dose to MEI: 0.0060 – 0.020 mrem/yr	Annual dose to MEI: 0.0061 – 0.026 mrem/yr
Annual cancer risk to MEI: 3×10^{-9} – 1×10^{-8} per year	Annual cancer risk to MEI: 3×10^{-9} – 1×10^{-8} per year	Annual cancer risk to MEI: 3×10^{-9} – 1×10^{-8} per year
Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem	Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem	Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem
Total number of LCFs in population within 50 miles: 2×10^{-5} – 6×10^{-5} LCF	Total number of LCFs in population within 50 miles: 2×10^{-5} – 6×10^{-5} LCF	Total number of LCFs in population within 50 miles: 2×10^{-5} – 6×10^{-5} LCF
<i>Human Health – Normal Operations: Chemical</i>		
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
No impacts	No impacts	No impacts
General Public:	General Public:	General Public:
No impacts	No impacts	No impacts

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Grouted U ₃ O ₈ in Vaults	Impacts from Disposal as Grouted U ₃ O ₈ in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 miles: 1.5 person-rem Number of LCFs in population within 50 miles: 0.0007 LCF	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 miles: 1.5 person-rem Number of LCFs in population within 50 miles: 0.0007 LCF	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 miles: 1.5 person-rem Number of LCFs in population within 50 miles: 0.0007 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): • Number of persons with potential for adverse effects: 1 person Number of persons with potential for irreversible adverse effects: 1 person	Noninvolved Workers: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 person Number of persons with potential for irreversible adverse effects: 1 person	Noninvolved Workers: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 person Number of persons with potential for irreversible adverse effects: 1 person
General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons	General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons	General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 persons Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Grouted U ₃ O ₈ in Vaults	Impacts from Disposal as Grouted U ₃ O ₈ in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: All Workers: Less than 1 (0.26) fatality, approximately 210 injuries	Construction and Operations: All Workers: Less than 1 (0.44) fatality, approximately 300 injuries	Construction and Operations: All Workers: Approximately 1 fatality, approximately 450 injuries
Air Quality		
Construction: Annual NO _x concentration potentially as large as 3% of standard; other criteria pollutant concentrations between 0.2 and 2% of respective standards	Construction: Annual NO _x concentration potentially as large as 13% of standard; other criteria pollutant concentration between 0.3 and 4% of respective standards	Construction: All pollutant concentrations below 0.1% of respective standards
Operations: Annual NO _x concentration potentially as large as 7% of standard; other criteria pollutant concentrations between 0.3 and 3% of respective standards	Operations: Annual NO _x concentration potentially as large as 37% of standard; other criteria pollutant concentrations between 0.8 and 10% of respective standards	Operations: All pollutant concentrations below 0.02% of respective standards
Water^b		
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater
Soil^b		
Construction: Negligible, but temporary, impacts	Construction: Moderate to large, but temporary, impacts	Construction: Moderate to large, but temporary, impacts
Operations: No impacts	Operations: No impacts	Operations: No impacts
Socioeconomics		
Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Grouted U ₃ O ₈ in Vaults	Impacts from Disposal as Grouted U ₃ O ₈ in a Mine
<i>Ecology</i>		
Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential large impacts to vegetation and wildlife	Construction: Potential large impacts to vegetation and wildlife
Operations: Potential adverse impacts to aquatic biota	Operations: Potential adverse impacts to aquatic biota	Operations: Potential adverse impacts to aquatic biota
<i>Waste Management</i>		
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
<i>Resource Requirements</i>		
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
<i>Land Use</i>		
Use of approximately 85 acres; potential moderate impacts	Use of approximately 149 acres; potential moderate impacts	Use of approximately 471 acres; potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction
B. Ungouted		
Impacts from Disposal as Ungouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Ungouted U ₃ O ₈ in Vaults	Impacts from Disposal as Ungouted U ₃ O ₈ in a Mine
<i>Human Health – Normal Operations: Radiological</i>		
Involved Workers: Total collective dose: 280 person-rem	Involved Workers: Total collective dose: 300 person-rem	Involved Workers: Total collective dose: 360 person-rem
Total number of LCFs: 0.1 LCF	Total number of LCFs: 0.1 LCF	Total number of LCFs: 0.1 LCF
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts
<i>Human Health – Normal Operations: Chemical</i>		
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts

TABLE I.2 (Cont.)

Impacts from Disposal as UngROUTED U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as UngROUTED U ₃ O ₈ in Vaults	Impacts from Disposal as UngROUTED U ₃ O ₈ in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 130 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 130 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 130 rem
Risk of LCF to MEI: 0.05	Risk of LCF to MEI: 0.05	Risk of LCF to MEI: 0.05
Collective dose: 5.6 person-rem	Collective dose: 5.6 person-rem	Collective dose: 5.6 person-rem
Number of LCFs: 0.002	Number of LCFs: 0.002	Number of LCFs: 0.002
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1 rem
Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}
Collective dose to population within 50 miles: 1.3 person-rem	Collective dose to population within 50 miles: 1.3 person-rem	Collective dose to population within 50 miles: 1.3 person-rem
Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.2 (Cont.)

Impacts from Disposal as Ungroued U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Ungroued U ₃ O ₈ in Vaults	Impacts from Disposal as Ungroued U ₃ O ₈ in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: All Workers: Less than 1 (0.13) fatality, approximately 90 injuries	Construction and Operations: All Workers: Less than 1 (0.22) fatality, approximately 140 injuries	Construction and Operations: All Workers: Less than 1 (0.53) fatality, approximately 240 injuries
Air Quality		
Construction: Annual NO _x concentration potentially as large as 1.3% of standard; all other criteria pollutant concentrations between 0.07 and 0.6% of respective standards	Construction: Annual NO _x concentration potentially as large as 3.5% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards	Construction: All pollutant concentrations below 0.1% of respective standards
Operations: Annual NO _x concentration potentially as large as 2.3% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards	Operations: Annual NO _x concentration potentially as large as 10% of standard; all other criteria pollutant concentrations between 0.3 and 3% of respective standards	Operations: All pollutant concentrations below 0.02% of respective standards
Water^b		
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater
Soil^b		
Construction: Negligible, but temporary, impacts	Construction: Moderate to large, but temporary, impacts	Construction: Moderate to large, but temporary, impacts
Operations: No impacts	Operations: No impacts	Operations: No impacts
Socioeconomics		
Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income

TABLE I.2 (Cont.)

Impacts from Disposal as UngROUTED U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as UngROUTED U ₃ O ₈ in Vaults	Impacts from Disposal as UngROUTED U ₃ O ₈ in a Mine
<i>Ecology</i>		
Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential large impacts to vegetation and wildlife
Operations: Negligible impacts	Operations: Negligible impacts	Operations: Negligible impacts
<i>Waste Management</i>		
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
<i>Resource Requirements</i>		
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
<i>Land Use</i>		
Use of approximately 46 acres; negligible impacts	Use of approximately 75 acres; potential moderate impacts	Use of approximately 232 acres; potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

^a Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

^b Impacts are based on a site that would be large compared to the area of the facility, with a nearby river having a minimum flow that would be large compared to water use and discharge requirements.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides; ROI = region of influence.

TABLE I.3 Summary of Disposal Option Impacts for UO₂ during the Operational Phase^a

A. Grouted

Impacts from Disposal as Grouted UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Grouted UO ₂ in Vaults	Impacts from Disposal as Grouted UO ₂ in a Mine
<i>Human Health – Normal Operations: Radiological</i>		
Involved Workers:	Involved Workers:	Involved Workers:
Total collective dose: 420 person-rem	Total collective dose: 440 person-rem	Total collective dose: 480 person-rem
Total number of LCFs: 0.2 LCF	Total number of LCFs: 0.2 LCF	Total number of LCFs: 0.2 LCF
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
Annual dose to MEI: 0.0032 – 0.017 mrem/yr	Annual dose to MEI: 0.0037 – 0.017 mrem/yr	Annual dose to MEI: 0.0016 – 0.016 mrem/yr
Annual cancer risk to MEI: 1×10^{-9} – 7×10^{-9} per year	Annual cancer risk to MEI: 1×10^{-9} – 7×10^{-9} per year	Annual cancer risk to MEI: 6×10^{-10} – 6×10^{-9} per year
Total collective dose: 0.00055 – 0.0036 person-rem	Total collective dose: 0.00061 – 0.0040 person-rem	Total collective dose: 0.00055 – 0.0036 person-rem
Total number of LCFs: 2×10^{-7} – 1×10^{-6} LCF	Total number of LCFs: 2×10^{-7} – 2×10^{-6} LCF	Total number of LCFs: 2×10^{-7} – 1×10^{-6} LCF
General Public:	General Public:	General Public:
Annual dose to MEI: 0.012 – 0.050 mrem/yr	Annual dose to MEI: 0.012 – 0.050 mrem/yr	Annual dose to MEI: 0.012 – 0.050 mrem/yr
Annual cancer risk to MEI: 6×10^{-9} – 2×10^{-8} per year	Annual cancer risk to MEI: 6×10^{-9} – 2×10^{-8} per year	Annual cancer risk to MEI: 6×10^{-9} – 2×10^{-8} per year
Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem	Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem	Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem
Total number of LCFs in population within 50 miles: 4×10^{-5} – 1×10^{-4} LCF	Total number of LCFs in population within 50 miles: 4×10^{-5} – 1×10^{-4} LCF	Total number of LCFs in population within 50 miles: 4×10^{-5} – 1×10^{-4} LCF
<i>Human Health – Normal Operations: Chemical</i>		
Noninvolved Workers:	Noninvolved Workers:	Noninvolved Workers:
No impacts	No impacts	No impacts
General Public:	General Public:	General Public:
No impacts	No impacts	No impacts

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Grouted UO ₂ in Vaults	Impacts from Disposal as Grouted UO ₂ in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem
Risk of LCF to MEI: 1×10^{-4}	Risk of LCF to MEI: 1×10^{-4}	Risk of LCF to MEI: 1×10^{-4}
Collective dose: 0.011 person-rem	Collective dose: 0.011 person-rem	Collective dose: 0.011 person-rem
Number of LCFs: 5×10^{-6}	Number of LCFs: 5×10^{-6}	Number of LCFs: 5×10^{-6}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem
Risk of LCF to MEI: 1×10^{-6}	Risk of LCF to MEI: 1×10^{-6}	Risk of LCF to MEI: 1×10^{-6}
Collective dose to population within 50 miles: 0.0027 person-rem	Collective dose to population within 50 miles: 0.0027 person-rem	Collective dose to population within 50 miles: 0.0027 person-rem
Number of LCFs in population within 50 miles: 1×10^{-6} LCF	Number of LCFs in population within 50 miles: 1×10^{-6} LCF	Number of LCFs in population within 50 miles: 1×10^{-6} LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Grouted UO ₂ in Vaults	Impacts from Disposal as Grouted UO ₂ in a Mine
<i>Human Health — Accidents: Physical Hazards</i>		
Construction and Operations: All Workers: Less than 1 (0.23) fatality, approximately 180 injuries	Construction and Operations: All Workers: Less than 1 (0.26) fatality, approximately 190 injuries	Construction and Operations: All Workers: Less than 1 (0.50) fatality, approximately 280 injuries
<i>Air Quality</i>		
Construction: Annual NO _x concentration potentially as large as 0.9% of standard; all other criteria pollutant concentrations between 0.05 and 0.6% of respective standards	Construction: Annual NO _x concentration potentially as large as 1% of standard; all other criteria pollutant concentrations between 0.04 and 0.4% of respective standards	Construction: All pollutant concentrations less than 10% of concentrations from shallow earthen structure construction
Operations: Annual NO _x concentration potentially as large as 1.8% of standard; all other criteria pollutant concentrations between 0.1 and 1.1% of respective standards	Operations: Annual NO _x concentration potentially as large as 5.6% of standard; all other criteria pollutant concentrations between 0.2 and 2% of respective standards	Operations: All pollutant concentrations about 10% of those from mine construction
<i>Water^b</i>		
Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater	Construction: Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater	Operations: None to negligible impacts to surface water and groundwater
<i>Soil^b</i>		
Construction: Negligible, but temporary, impacts	Construction: Moderate to large, but temporary, impacts	Construction: Moderate to large, but temporary, impacts
Operations: No impacts	Operations: No impacts	Operations: No impacts
<i>Socioeconomics</i>		
Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income	Construction: Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income	Operations: Potential moderate impacts on employment and income

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Grouted UO ₂ in Vaults	Impacts from Disposal as Grouted UO ₂ in a Mine
<i>Ecology</i>		
Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential moderate impacts to vegetation and wildlife	Construction: Potential large impacts to vegetation and wildlife
Operations: Potential adverse impacts to aquatic biota	Operations: Potential adverse impacts to aquatic biota	Operations: Potential adverse impacts to aquatic biota
<i>Waste Management</i>		
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
<i>Resource Requirements</i>		
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
<i>Land Use</i>		
Use of approximately 39 acres; negligible impacts	Use of approximately 41 acres; negligible impacts	Use of approximately 149 acres; potential moderate impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction
B. UngROUTED		
Impacts from Disposal as UngROUTED UO ₂ in Shallow Earthen Structures	Impacts from Disposal as UngROUTED UO ₂ in Vaults	Impacts from Disposal as UngROUTED UO ₂ in a Mine
<i>Human Health – Normal Operations: Radiological</i>		
Involved Workers: Total collective dose: 170 person-rem	Involved Workers: Total collective dose: 220 person-rem	Involved Workers: Total collective dose: 240 person-rem
Total number of LCFs: 0.07 LCF	Total number of LCFs: 0.09 LCF	Total number of LCFs: 0.09 LCF
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts
<i>Human Health – Normal Operations: Chemical</i>		
Noninvolved Workers: No impacts	Noninvolved Workers: No impacts	Noninvolved Workers: No impacts
General Public: No impacts	General Public: No impacts	General Public: No impacts

TABLE I.3 (Cont.)

Impacts from Disposal as Ungrouped UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Ungrouped UO ₂ in Vaults	Impacts from Disposal as Ungrouped UO ₂ in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem	Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem
Risk of LCF to MEI: 9×10^{-5}	Risk of LCF to MEI: 9×10^{-5}	Risk of LCF to MEI: 9×10^{-5}
Collective dose: 12 person-rem	Collective dose: 12 person-rem	Collective dose: 12 person-rem
Number of LCFs: 0.005	Number of LCFs: 0.005	Number of LCFs: 0.005
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem	General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem
Risk of LCF to MEI: 8×10^{-7}	Risk of LCF to MEI: 8×10^{-7}	Risk of LCF to MEI: 8×10^{-7}
Collective dose to population within 50 miles: 0.046 person-rem	Collective dose to population within 50 miles: 0.046 person-rem	Collective dose to population within 50 miles: 0.046 person-rem
Number of LCFs in population within 50 miles: 2×10^{-5} LCF	Number of LCFs in population within 50 miles: 2×10^{-5} LCF	Number of LCFs in population within 50 miles: 2×10^{-5} LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):	Noninvolved Workers: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):	General Public: Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.3 (Cont.)

Impacts from Disposal as UngROUTED UO ₂ in Shallow Earthen Structures	Impacts from Disposal as UngROUTED UO ₂ in Vaults	Impacts from Disposal as UngROUTED UO ₂ in a Mine
<i>Human Health — Accidents: Physical Hazards</i>		
<p>Construction and Operations: All Workers: Less than 1 (0.13) fatality, approximately 90 injuries</p>	<p>Construction and Operations: All Workers: Less than 1 (0.15) fatality, approximately 110 injuries</p>	<p>Construction and Operations: All Workers: Less than 1 (0.33) fatality, approximately 170 injuries</p>
<i>Air Quality</i>		
<p>Construction: Annual NO_x concentration potentially as large as 0.6% of standard; all other criteria pollutant concentrations between 0.04 and 0.4% of respective standards</p>	<p>Construction: Annual NO_x concentration potentially as large as 0.6% of standard; all other criteria pollutant concentrations between 0.03 and 0.3% of respective standards</p>	<p>Construction: All pollutant concentrations less than 10% of concentration from shallow earthen structure construction</p>
<p>Operations: Annual NO_x concentration potentially as large as 1.3% of standard; all other criteria pollutant concentrations between 0.08 and 0.8% of respective standards</p>	<p>Operations: Annual NO_x concentration potentially as large as 3.3% of standard; all other criteria pollutant concentrations between 0.1 and 1.3% of respective standards</p>	<p>Operations: All pollutant concentrations about 10% of those from mine construction</p>
<i>Water^b</i>		
<p>Construction: Negligible impacts to surface water and groundwater</p>	<p>Construction: Negligible impacts to surface water and groundwater</p>	<p>Construction: Negligible impacts to surface water and groundwater</p>
<p>Operations: None to negligible impacts to surface water and groundwater</p>	<p>Operations: None to negligible impacts to surface water and groundwater</p>	<p>Operations: None to negligible impacts to surface water and groundwater</p>
<i>Soil^b</i>		
<p>Construction: Negligible, but temporary, impacts</p>	<p>Construction: Moderate to large, but temporary, impacts</p>	<p>Construction: Moderate to large, but temporary, impacts</p>
<p>Operations: No impacts</p>	<p>Operations: No impacts</p>	<p>Operations: No impacts</p>
<i>Socioeconomics</i>		
<p>Potential moderate impacts on employment and income</p>	<p>Potential moderate impacts on employment and income</p>	<p>Potential moderate impacts on employment and income</p>
<i>Ecology</i>		
<p>Construction: Potential moderate impacts to vegetation and wildlife</p>	<p>Construction: Potential moderate impacts to vegetation and wildlife</p>	<p>Construction: Potential large impacts to vegetation and wildlife</p>
<p>Operations: Negligible impacts</p>	<p>Operations: Negligible impacts</p>	<p>Operations: Negligible impacts</p>

TABLE I.3 (Cont.)

Impacts from Disposal as Ungrouned UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Ungrouned UO ₂ in Vaults	Impacts from Disposal as Ungrouned UO ₂ in a Mine
<i>Waste Management</i>		
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
<i>Resource Requirements</i>		
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
<i>Land Use</i>		
Use of approximately 28 acres; negligible impacts	Use of approximately 28 acres; negligible impacts	Use of approximately 102 acres; potential moderate impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

^a Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

^b Impacts are based on a site that would be large compared to the area of the facility, with a nearby river having a minimum flow that would be large compared to water use and discharge requirements.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides; ROI = region of influence.

- **Shallow Earthen Structure, Vault, or Mine.** The potential impacts are essentially similar for disposal in a shallow earthen structure, vault, or mine. However, disposal in a mine could create slightly larger potential impacts if excavation of the mine was required (use of an existing mine would minimize impacts).

For the post-closure phase, the potential environmental impacts for disposal of U₃O₈ and UO₂ are summarized in Tables I.4 and I.5, respectively. Impacts were calculated for a post-failure time of 1,000 years. The potential impacts estimated for the post-closure phase are subject to a great deal of uncertainty because of the extremely long time period considered and the dependence of predictions on the behavior of the waste material as it interacts with soil and water in a distant future environment. The post-closure impacts would depend greatly on the specific disposal facility design and site-specific characteristics. Because of these uncertainties, the assessment assumptions are generally selected to produce conservative estimates of impact, that is, they tend to overestimate the expected impact. Changes in key disposal assumptions could yield significantly different results (see Section I.4).

The following is presented as a general summary of potential environmental impacts during the post-closure phase (from information in Tables I.4 and I.5 and Section I.4):

- **Potential Adverse Impacts.** For all disposal options, potentially large impacts to human health and groundwater quality could occur within 1,000 years after failure of a facility in a wet setting, whereas essentially no impacts would occur for a dry setting in the same time frame. Potential impacts would result primarily from the contamination of groundwater. The maximum dose to an individual assumed to live at the edge of the disposal site and use the contaminated water was estimated to be about 110 mrem/yr, which would exceed the 25-mrem/yr limit specified in 10 *Code of Federal Regulations* [CFR] Part 61 and DOE Order 5820.2A. (For comparison, the average dose to an individual from background radiation is about 360 mrem/yr.) Possible exposures (on the order of 10 rem/yr) could occur for shallow earthen structures and vaults if the cover material were to erode and expose the uranium material; however, this would not occur until several thousand years later, and the exposure could be eliminated by adding new cover material to the top of the waste area.
- **Wet or Dry Environmental Setting.** The potential impacts would be significantly greater in a wet setting than a dry setting. Essentially no impacts would be expected in a dry setting for more than 1,000 years because of the low water infiltration rate and greater depth to the water table.

TABLE I.4 Summary of Disposal Option Impacts for U₃O₈ during the Post-Closure Phase^{a,b}

A. Grouted

Impacts from Disposal as Grouted U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Grouted U ₃ O ₈ in Vaults	Impacts from Disposal as Grouted U ₃ O ₈ in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 49 – 72 mrem/yr	General Public: Annual dose to MEI: 57 – 84 mrem/yr	General Public: Annual dose to MEI: 1 – 110 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 4 \times 10^{-5}$ per year	Annual cancer risk to MEI: $3 \times 10^{-5} - 4 \times 10^{-4}$ per year	Annual cancer risk to MEI: $4 \times 10^{-7} - 5 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined
Human Health: Chemical		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
Water		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
Ecology		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

B. UngROUTED

Impacts from Disposal as UngROUTED U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as UngROUTED U ₃ O ₈ in Vaults	Impacts from Disposal as UngROUTED U ₃ O ₈ in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 41 – 60 mrem/yr	General Public: Annual dose to MEI: 48 – 70 mrem/yr	General Public: Annual dose to MEI: 1 – 93 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $2 \times 10^{-5} - 4 \times 10^{-5}$ per year	Annual cancer risk to MEI: $4 \times 10^{-7} - 5 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined

TABLE I.4 (Cont.)

Impacts from Disposal as Ungrouned U ₃ O ₈ in Shallow Earthen Structures	Impacts from Disposal as Ungrouned U ₃ O ₈ in Vaults	Impacts from Disposal as Ungrouned U ₃ O ₈ in a Mine
<i>Human Health: Chemical</i>		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
<i>Water</i>		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
<i>Ecology</i>		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

^a Impacts for the post-closure phase were calculated for a time 1,000 years after each disposal facility was assumed to fail. Impacts are presented for a generic wet setting; no impacts would be expected within 1,000 years in a dry setting.

^b All disposal facilities would be designed to contain the waste material for at least hundreds of years. Shallow earthen structures would be expected to last several hundred years before failure; vaults and mines would be expected to last several hundreds to thousands of years before failure.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE I.5 Summary of Disposal Option Impacts for UO₂ during the Post-Closure Phase^{a,b}

A. Grouted

Impacts from Disposal as Grouted UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Grouted UO ₂ in Vaults	Impacts from Disposal as Grouted UO ₂ in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 37 – 54 mrem/yr	General Public: Annual dose to MEI: 38 – 56 mrem/yr	General Public: Annual dose to MEI: 1 – 84 mrem/yr
Annual cancer risk to MEI: 2×10^{-5} – 3×10^{-5} per year	Annual cancer risk to MEI: 2×10^{-5} – 3×10^{-5} per year	Annual cancer risk to MEI: 3×10^{-7} – 4×10^{-5} per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined
Human Health: Chemical		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
Water		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
Ecology		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

B. UngROUTed

Impacts from Disposal as UngROUTed UO ₂ in Shallow Earthen Structures	Impacts from Disposal as UngROUTed UO ₂ in Vaults	Impacts from Disposal as UngROUTed UO ₂ in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 34 – 50 mrem/yr	General Public: Annual dose to MEI: 34 – 50 mrem/yr	General Public: Annual dose to MEI: 1 – 77 mrem/yr
Annual cancer risk to MEI: 2×10^{-5} – 3×10^{-5} per year	Annual cancer risk to MEI: 2×10^{-5} – 3×10^{-5} per year	Annual cancer risk to MEI: 2×10^{-7} – 4×10^{-5} per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined

TABLE I.5 (Cont.)

Impacts from Disposal as Ungrouned UO ₂ in Shallow Earthen Structures	Impacts from Disposal as Ungrouned UO ₂ in Vaults	Impacts from Disposal as Ungrouned UO ₂ in a Mine
<i>Human Health: Chemical</i>		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
<i>Water</i>		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
<i>Ecology</i>		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

^a Impacts for the post-closure phase were calculated for a time 1,000 years after each disposal facility was assumed to fail. Impacts are presented for a generic wet setting; no impacts would be expected within 1,000 years in a dry setting.

^b All disposal facilities would be designed to contain the waste material for at least hundreds of years. Shallow earthen structures would be expected to last several hundred years before failure; vaults and mines would be expected to last several hundreds to thousands of years before failure.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual.