APPENDIX D

RADIATION DOSE AND RISK ASSESSMENTS

D. RADIATION DOSE AND RISK ASSESSMENTS

This appendix describes the analysis of potential health impacts from the licensee's proposed action to conduct surface reclamation of its Gore, Oklahoma, site and alternatives to the proposed action. This appendix contains two major sections—a discussion of the residual contamination present at the Sequoyah Fuels Corporation (SFC) site (Section D.1); and the radiation dose and risk modeling for workers and members of the public (Section D.2).

D.1 Residual Contamination

Table D-1 lists the six areas on the SFC site that are contaminated with radioactive materials. SFC had already completed remediation activities on contamination in two additional areas, Areas 7 and 8, before development of this EIS; therefore, this analysis did not consider those areas (Camper, 2000). Table D-2 lists the surface area and depth of each contaminated area. The analysis used the monitoring and sampling data that Roberts/Schnorinick collected at the SFC site (RSA, 1996) to determine the level of contamination in each of the six areas and soil source terms for contiguous areas of relatively homogeneous contamination. In addition, RSA identified subareas of specific contamination that are dissimilar to the homogeneous soil source term for the contaminated area. Based on the evaluation of soil contamination data, the staff of the U.S. Nuclear Regulatory Commission (NRC) determined that the constituents of concern (COC) are arsenic, fluoride, nitrate, and uranium. The NRC staff made this determination based on the concentrations and potential environmental impacts of the contaminants. In addition, NRC staff included thorium-230 and radium-226 to enable a more complete evaluation of potential radiation doses. Table D-3 summarizes the COC concentrations at the SFC site and provides overall average concentrations of the radioactive constituents in units of becquerels (picocuries) per gram.

Table D-1 Contaminated Areas on the SFC Site

Contaminated Area	Description
1	Fluoride Clarifier, two Fluoride Settling Basins, Fluoride Holding Basin No. 1, four Fluoride Sludge Burial Areas
2	Four Clarifier A Basins, Pond 1 and 2, Spoils Pile, Former Raffinate Treatment Area, Former BaCl Mixing Area, Centrifuge Building, Injection Well
3	Main Process Building, Solvent Waste Building, Emergency Basin, Sanitary Lagoon, North Ditch, Incinerator, Solid Waste Building, South Yellow Cake Sump, Yellow Cake Storage Pad, Combination Stream, Present Lime Neutralization Area, Sanitary Sewer, Line, North Tank Farm, South Tank Farm, Cooling Tower, ADU/Miscellaneous Digestion Bldg., Bechtel Storage Building, Oil Storage Building, RCC Evaporator
4	Two Solid Waste Burial Areas, Interim Storage Cell, Scrap Metal Storage Area
5	Four Fertilizer Storage Ponds, Fertilizer Loadout Area, Pond 4
6	Fluoride Holding Basin No. 2

Source: SFC, 1998.

Table D-2 Size of Contaminated Areas

Contaminated Area	Surface Area (m^2)	Soil Depth (m)
1 – No Data from the Source	N/A	N/A
2 – Soils	26,110	1.0
Pond 2	18,835	2.6
Clarifiers	12,030	1.5
3 – Soils	26,110	1.5
North Ditch	1,212	0.5
Emergency Basin	3,542	0.1
Sanitary Lagoon	2,883	0.2
10a Source	10	1.0
4 – Soils	21,500	1.5
5 – Soils	18,950	1.5
6– Soils	1,160	1.5
Sludges	3,340	1.6

Source: RSA, 1996.
N/A– Not Available.

Table D-3 Existing Contamination Concentrations by Contaminated Area

Contaminated Area	Arsenic (mg/kg)	Fluoride (mg/kg)	Nitrate (mg/kg)	Uranium (mg/kg)	Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium -226 Bq/g (pCi/g)
1 – Soils	5	460	55.7	26.5	0.37 (10)	0.13 (3.5)	0.0054 (0.2)
Sludges	133	31,800	205	460	0.63 (173)	6.9 (186)	0.011 (0.3)
2 – Soils	5	529	507.7	15.0	0.21 (5.6)	1.8 (49.7)	0.77 (2.1)
Pond 2	--	1,640	5,450	607	4.4 (118)	72 (1,950)	2.5 (66.3)
Clarifiers	1,350	33,100	27,300	15,900	221 (5,978)	756 (20,400)	12 (317)
3 – Soils	--	572	65.4	424	5.9 (159)	2.1 (56)	0.11 (2.92)
North Ditch	37.5	9,100	510	17,600	245 (6,618)	86 (2,320)	4.4 (120)
Emergency Basin	97.5	6,840	24.9	7,470	104 (2,809)	103 (2,785)	9.1 (245)
Sanitary Lagoon	440	2,680	228	24,300	338 (9,137)	14 (384)	0.25 (6.7)
10a Source	--	1,050	2.4	3,970	55 (1,493)	19 (525)	1 (27)
4– Soils	5	396	36	432.6	6 (163)	1.1 (28.8)	0.037 (0.99)

Table D-3 Existing Contamination Concentrations by Contaminated Area

Contaminated Area	Arsenic (mg/kg)	Fluoride (mg/kg)	Nitrate (mg/kg)	Uranium (mg/kg)	Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium -226 Bq/g (pCi/g)
5– Soils	5	258	4.4	10.7	0.15 (4)	0.85 (2.3)	0.67 (1.8)
6- Soils	18.5	507	45.5	22.9	0.32 (8.6)	0.11 (3.0)	0.0074 (0.2)
Sludges	7.3	39,900	242	1,280	18 (481)	7 (190)	0.59 (1.6)
Overall Average	**N/A**	**N/A**	**N/A**	**5,180**	**72 (1,940)**	**76 (2,063)**	**2.6 (71)**

Source: RSA, 1996.
N/A– Not Available

D.2 Radiation Dose and Risk Modeling

The analysis for this EIS considered the following potential public and occupational impacts:

- Radiation doses and risks for members of the public during reclamation. The NRC staff considered the affected population to be that within 80 kilometers (50 miles) of the SFC facility; the primary exposure pathway would be from radioactive material suspended in the air from reclamation operations.

- Long-term doses and risks for individuals who inhabit the site. Because of the long half-lives of the radioactive materials at SFC, it may be possible that individuals could potentially inhabit both the unrestricted and restricted portions of the site if loss of institutional controls or license conditions occurs, depending on the alternative.

- Potential impacts on radiation workers during reclamation for the average and maximally exposed workers and the average collective workforce.

- Impacts on workers during institutional controls for average workers.

- Exposures to hazardous chemicals.

- Fatalities and injuries in the workforce during reclamation activities.

No high-energy sources (e.g., explosives or nuclear fuel) capable of driving off-site releases that could lead to criticality accidents would be involved during reclamation, unlike normal facility operations; therefore, there would be little potential for off-site consequences from accidents during reclamation. This analysis of public health impacts concluded that the impacts for transportation of radioactive wastes off the site would bound those from any on-site accidents. Therefore, this analysis did not consider accidents during on-site reclamation activities that could involve off-site members of the public.

Title 10, "Energy," of *the U.S. Code of Federal Regulations* (CFR), Part 20 (10 CFR Part 20), contains the regulations that govern reclamation of the SFC facility and remediation of the site before license termination. This regulation provides the regulatory limits for occupational doses and radiation dose for individual members of the off-site public. For occupational doses, 10 CFR § 20.1201 states that licensees must limit the occupational dose to individual adults to an annual limit based on the more limiting of:

- The total effective dose equivalent (TEDE) being equal to 0.05 sievert (5 rem), or
- 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 being equal to 0.5 sievert (50 rem).

The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities are:

- A lens dose equivalent of 0.15 sievert (15 rem).
- A shallow-dose equivalent of 0.5 sievert (50 rem) to the skin of the whole body.
- A shallow-dose equivalent of 0.5 sievert (50 rem) to the skin of any extremity.

In addition to the annual occupational dose limits, 10 CFR § 20.1201 limits the soluble uranium intake by an individual to 10 milligrams in a week because of chemical toxicity.

For members of the public during reclamation, and for industrial workers during long-term maintenance periods who are assumed to be members of the public, the regulation provides an explicit TEDE limit of 1.0 millisievert (100 millirem) per year from all sources. This limit includes both internal and external doses through all pathways, including food, as required by specific exposure scenarios. External dose rates cannot exceed 0.02 millisievert (2 millirem) in any 1 hour. Further, the standards in 10 CFR § 20.1101 and 40 CFR Part 190 would be generally applicable during reclamation; 40 CFR Part 190 requires that routine releases from uranium fuel-cycle facilities to the general environment do not result in annual doses above 0.25 millisievert (25 millirem) to the whole body, 0.75 millisievert (75 millirem) to the thyroid, and 0.25 millisievert (25 millirem) to any other organ.

For alternatives that would result in unrestricted release of the site, doses to members of the public are limited by determining the cleanup levels (CLs) using the benchmark dose approach in 10 CFR Part 40, Appendix A. As described in Section D.2.1.3, the analysis based the CLs on a fraction of the benchmark dose for radium of 0.54 millisievert (54 millirem) per year.

The following sections present the methods, models, and data the analysis used to estimate potential public and occupational health impacts. Section D.2.1 discusses the impacts from on-site disposal of only contaminated materials (Alternative 1, which is the proposed action); Section D.2.2 addresses off-site disposal of all contaminated materials (Alternative 2); Section D.2.3 addresses partial off-site disposal of contaminated materials (Alternative 3); and Section D.2.4 addresses the impacts of the no-action alternative.

D.2.1 Alternative 1: On-site Disposal of Contaminated Materials (the Licensee's Proposed Action) – Doses to Members of the Public

SFC proposes to decontaminate, dismantle, and decommission its licensed activities at its site near Gore, Oklahoma. The facility was a chemical plant that converted uranium ore concentrate (yellowcake) to UF_6 and depleted UF_6 to depleted UF_4. SFC's proposed action is on-site disposal of all contaminated materials (Alternative 1). For Alternative 1, SFC would place contaminated soils and other sources (building rubble, sludge, residue, and sediment) with concentrations that exceeded the Derived Concentration Guideline Levels (DCGLs) within an institutional control boundary (ICB) in an on-site disposal cell. The estimated concentrations of specific radionuclides are provided in Table D-4. SFC proposes to maintain all contaminated areas within a restricted area. The above-grade disposal cell would cover about 4 hectares (10 acres). The ICB would restrict unauthorized personnel access to the area. SFC would design the engineered disposal cell to comply with the NRC performance standards, which are outlined in Appendix A of 10 CFR Part 40.

Table D-4 On-site Disposal Material Summary

Layer	Description	Natural Uranium Bq/g (pCi/g)	Radium-226 Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)
A	Sludge and Sediment	13-448 (17-587)	0.22-12 (0.29-16)	7.8-604 (10-791)
B	Liner Soils and Subsoils	0.19-3.5 (0.25-4.6)	0.019-0.78 (0.025-1.0)	1.7-2.6 (47-70)
C	Calcium Fluoride Sediments, Debris	6.2-19 (8.1-14.5)	0.0074-0.029 (0.0084-0.038)	0.078-0.18 (0.10-0.24)
D	Contaminated Site Soils	9.3 (12.2)	– –	– –

Source: Reclamation Plan, Attachment E, Table 2.1 (SFC, 2005).

D.2.1.1 Alternative 1: Off-site Public Radiation Doses and Risks during Reclamation

Off-site public exposures would occur because of the atmospheric release of radionuclides in soil suspended in air. This would occur during the movement of material from the known contaminated areas to the disposal cell in the ICB. SFC collected off-site air samples during previous reclamation activities at the site. The determination of potential public doses used these samples in an inhalation modeling analysis to provide a reasonable basis for the estimation of the potential off-site public radiation doses for Alternative 1. The analysis used SFC air-monitoring data from the nearest residence air sampler for the period from 1995 through 1998 (SFC, 2005; see Table D-5) to estimate inhalation committed effective dose equivalents (CEDEs). The NRC staff consider this location to be the location of the maximally exposed individual (MEI) in the public. These estimated inhalation doses range from 0.003 to 0.005 millisievert (0.3 to 0.5 millirem) per year. These doses are a small fraction of the 0.25-millisievert-per-year (25-millirem-per-year) limit for site operations and are considered to be as low as reasonably achievable (ALARA). This analysis used 0.005 millisievert (0.5 millirem) per year as the annual dose to the MEI in the public during reclamation. For comparison, an average individual living in Oklahoma receives a radiation dose of about 3.6 millisievert (360 millirem) per year from all sources (NCRP, 1987). The lifetime doses the MEI would receive during the four-year reclamation period, and assuming constant off-site public doses over this period, would be about 0.02 millisievert (2 millirem) under Alternative 1.

Table D-5 Inhalation doses (CEDE) at the Nearest Resident Air-Monitoring Station of SFC

Year	CEDE mSv/yr (mrem/yr)
1995	0.005 (0.5)
1996	0.004 (0.4)
1997	0.003 (0.3)
1998	0.003 (0.3)

Source: SFC, 2005, Table 4-3.
mSv– millisievert; yr– year; mrem– millirem.

The analysis next compared inhalation dose assessments for a similar reclamation project that involved similar radionuclides and mixtures. Table D-6 lists the Weldon Spring Site reclamation inhalation dose estimates for 1994 through 1997. The analysis concluded that the Weldon Spring doses are comparable to those based on air concentration measurements at SFC during previous reclamation activities, and that they are less than 0.01 millisievert (1 millirem) per year.

Because the estimated public radiation dose rapidly decreases with distance downwind due to dispersion of the airborne contaminants, the assumption that 1,000 individuals would receive the MEI dose would bound the total collective population dose. This would equal 0.005 person-sievert (0.5 person-rem) per year. Again, the analysis assumed that reclamation activities would occur over a four-year period, so the estimated potential total collective dose to the off-site population would be 0.02 person-sievert (2 person-rem) for Alternative 1.

Table D-6 Inhalation Doses (CEDE) to the Hypothetical MEI Member of the Public at the Weldon Spring Site Remedial Action Project

Year	CEDE mSv/yr (mrem/yr)
1994	0.002 (0.2)
1995	0.002 (0.2)
1996	0.009 (0.9)
1997	0.002 (0.2)

Source: Environmental Report (SFC, 2005), Table 4-4.

The analysis estimated the probabilities of latent cancer fatalities (LCFs) for members of the public using a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) for members of the public during the four-year reclamation period. The U.S. Environmental Protection Agency (EPA) recommended this factor for the general population of the United States (Eckerman et al., 1999). This factor

Latent cancer fatalities (LCFs) are potential cancer deaths caused by exposure to ionizing radiation. They are derived and based on scientific evaluation of exposed populations, including the Japanese survivors of nuclear weapons detonations. Multiplying the annual or lifetime considers all age groups within the population, including infants and children, who are more sensitive to radiation than adults. Because workers are 18 years of age or older, the analysis used a separate, smaller dose-to-risk conversion factor for workers, as recommended by the International Commission on Radiological Protection (ICRP), of 4×10^{-5} per millisievert (4×10^{-7} per millirem) (ICRP, 1990, p. 22).

Table D-7 lists the estimated probabilities of LCFs to the MEI and the off-site collective population, both for a single year and for the total reclamation period. The estimated total population probability of an LCF would be low (1.2×10^{-3}), and the annual radiation doses would be within the regulatory limit on annual doses, i.e., less than 0.25 millisievert (25 millirem) per year; therefore, the significance level of public radiation exposures and risks for reclamation activities for Alternative 1 would be SMALL.

Table D-7 Estimated Probabilities of LCFs for the MEI and the Collective Population for Alternative 1

Individual Annual Risk	Individual Lifetime Risk[a]	Collective Annual Risk	Collective Lifetime Risk[a]
3.0×10^{-7}	1.2×10^{-6}	3.0×10^{-4}	1.2×10^{-3}

[a] Over the four years of reclamation activities.

D.2.1.2 Alternative 1: Worker Radiation Doses and Risks during Reclamation

> **Derived air concentration (DAC)** means the concentration of a given radionuclide in air that, if breathed by the reference person for a working year of 2,000 hours under conditions of light work (at an inhalation rate of 1.2 cubic meters [42 cubic feet] of air per hour), results in an intake of the annual limit on intake (ALI). The ALI is the derived limit for the amount of radioactive material taken into the body of an adult worker that would result in a CEDE of 50 millisievert (5 rem) per year.

The analysis based the estimates of radiation doses to reclamation workers for Alternative 1 on measured doses to workers during the raffinate sludge dewatering project, a previous reclamation activity at the SFC site. The worker doses from this previous reclamation project will bound the worker doses from other reclamation activities since the radionuclide concentrations were higher than will be encountered for other reclamation activities. Table D-8 summarizes the SFC exposures for the raffinate sludge dewatering project during the second and third quarters of 2005. The table lists the work activities, external deep dose equivalents, and the derived air concentration (DAC)-hours of inhalation intake. The DAC is the air concentration of a specific radionuclide that, if inhaled for a normal work year (2,000 hours), would result in the occupational dose limit of 50 millisievert (5 rem per year). Table D-8 lists the average doses and DAC-hours for each quarter, the averages over the two quarters, and the estimated annual average worker external doses and DAC-hours. The annual average DAC-hours translate into dose through division of the average DAC-hours by 2,000 hours of exposure in a year and multiplication by 50 millisievert (5 rem) per year—the basis of the DAC calculation. The maximum annual worker dose would be for the Press Washdown work activity.

Table D-8 SFC Raffinate Sludge Dewatering Project Exposure and Alternative 1: Estimated Average and Maximum Worker Doses and Intakes

	Average Worker Exposure	
Work Activity	**External[a] mSv (mrem)**	**Internal DAC-hr**
Second Quarter– 2005		
Sludge Transfer	0.31 (31)	47
Press Operation	0.37 (37)	122
Press Washdown	0.25 (25)	104
Filter Cake Bagging	0.26 (26)	46
Forklift Operation	0.33 (33)	0.5
Bag Stacking	0.47 (47)	0.7
Health and Safety Support	0.22 (22)	0
Second Quarter Average	**0.32 (32)**	**46**
Third Quarter– 2005		
Sludge Transfer	0.28 (28)	98.8
Press Operation	0.55 (55)	141
Press Washdown	0.35 (35)	152
Filter Cake Bagging	0.47 (47)	131
Forklift Operation	0.27 (27)	2
Bag Stacking	0.29 (29)	5.7
Health and Safety Support	0.19 (19)	1.1
Third Quarter Average	**0.34 (34)**	**76**
Second and Third Quarter Average	**0.33(33)**	**61**
Estimated Annual Totals	**1.32 (132)**	**244**

[a] As measured by thermoluminescent dosimeters.

As listed in Table D-9, the estimated annual TEDE to workers for Alternative 1, based on measured worker doses and intakes from the raffinate sludge-dewatering project, would be 7.47 millisievert (747 millirem) per year. This annual TEDE would bound the annual doses to reclamation workers for Alternative 1 because the average radionuclide concentrations at the site are only about 30% of the concentrations encountered during the raffinate sludge-dewatering project. The best estimate of annual worker doses using average radionuclide concentrations would be 30% of the raffinate sludge dewatering project doses, or about 2.2 millisievert (220 millirem) per year. Both the bounding and best-estimate worker annual TEDEs are within the NRC occupational radiation protection standard of 50 millisievert (5 rem) per year. Total doses to a worker during the four years of reclamation activities, assuming a worker is employed at the same task for the entire period, and assuming that the annual average TEDEs remain constant, would result in a worker lifetime TEDE of about 8.8 millisievert (880 millirem).

The analysis estimated the total collective dose to the workforce and the probabilities of LCFs to that workforce for Alternative 1, using the radiation worker labor force summarized by quarter and labor category in Table D-10. The resulting estimated TEDEs by quarter and year, and the estimated probabilities of LCFs by year, are presented in Table D-11. The estimated probabilities of LCFs were developed using a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) for industrial workers (ICRP, 1990). Table D-12 summarizes the estimated annual probabilities of LCFs to the average and maximum individual worker, the lifetime probability of an LCF to the average worker, and the collective worker population for the four-year reclamation period.

The estimated total worker probability of an LCF would be low (1.3×10^{-2}), and the annual worker radiation doses would be within the regulatory limit of 50 millisievert (5 rem) per year; therefore, the significance level of worker radiation exposures and risks for reclamation activities for Alternative 1 would be SMALL.

Table D-9 Estimated Bounding Worker Annual TEDEs for Alternative 1

Dose Estimate	External[a] mSv/yr (mrem/yr)	Internal Exposure DAC-hr/yr	Internal Dose mSv/yr (mrem/yr)[b]	Annual TEDE mSv/yr (mrem/yr)
Raffinate Sludge Dewatering Project–Projected Annual Totals	1.32 (132)	244	6.1 (610)	7.4 (740)
Estimated Annual Averages for Alternative 1[c]	0.4 (40)	73	1.8 (180)	2.2 (220)

[a] As measured by thermoluminescent dosimeters.
[b] Converted from DAC-hours per year by dividing by 2,000 and multiplying by 50 millisievert (5 rem) per year.
[c] Estimated assuming annual worker doses are 30% of the annual doses that SFC recorded for the raffinate sludge dewatering project, accounting for the average waste concentrations encountered.

Table D-10 Radiation Worker Manpower Estimates for Alternative 1

Quarter	Cell Closure	H&S Technicians	Equipment Operators	On-site Truck Drivers	Welders and Riggers	Laborers	Total
1	0	10	8	8	6	25	57
2	0	10	8	8	6	25	57
3	0	10	8	8	6	25	57
4	0	10	8	8	6	25	57
5	0	10	8	8	6	25	57
6	0	10	8	8	6	25	57
7	0	10	8	8	6	25	57
8	0	10	8	8	6	25	57
9	0	4	3	3	0	15	33
10	8	4	3	3	0	15	33
11	8	4	3	3	0	10	20
12	0	4	3	3	0	10	20
13	0	4	1	1	0	5	11
14	0	4	1	1	0	5	11
15	0	4	1	1	0	5	11
16	0	4	1	1	0	5	11

Table D-11 Collective Radiation Worker TEDEs and Estimated Probabilities of LCFs for Alternative 1

Quarter/Year	Estimated TEDE person-Sv (person-rem)	Estimated Total Collective Worker Risk
1	0.031 (3.1)	-
2	0.031 (3.1)	-
3	0.031 (3.1)	-
4	0.031 (3.1)	-
Total Year 1	**0.124 (12.4)**	**5.0×10^{-3}**
5	0.031 (3.1)	-
6	0.031 (3.1)	-
7	0.031 (3.1)	-
8	0.031 (3.1)	-
Total Year 2	**0.124 (12.4)**	**5.0×10^{-3}**
9	0.018 (1.8)	
10	0.018 (1.8)	
11	0.011 (1.1)	
12	0.011 (1.1)	
Total Year 3	**0.058 (5.8)**	**2.3×10^{-3}**
13	0.0060 (0.6)	-
14	0.0060 (0.6)	-
15	0.0060 (0.6)	-
16	0.0060 (0.6)	-
Total Year 4	**0.024 (2.4)**	**9.6×10^{-4}**
Total Over 4 Years	**0.33 (33)**	**1.3×10^{-2}**

Table D-12 Estimated Probabilities of LCFs for Reclamation Workers and the Collective Worker Population for Alternative 1

Average Individual Worker Annual Risk	Average Individual Worker Lifetime Risk[a]	Maximum Individual Worker Annual Risk[b]	Total Collective Average Worker[c]
8.8×10^{-5}	3.5×10^{-4}	3.0×10^{-4}	1.3×10^{-2}

[a] Over four years of reclamation activities.

[b] Assuming the doses received during the SFC raffinate sludge dewatering project represent the maximum worker doses.

[c] Over the entire radiation worker workforce during four years of reclamation activities.

D.2.1.3 Alternative 1: Long-term Public Radiation Doses and Risks

SFC derived the CLs for the restricted and unrestricted areas of the site. For the restricted areas of the site, SFC derived the DCGLs without consideration of any institutional controls for the dose received from pathways related to residual radioactive materials in surface soil. SFC based the derivation of the DCGLs on a radiation exposure scenario analysis using the RESRAD computer program (Yu et. al., 2001) and applied the benchmark dose approach.

Appendix A, "Radiological Criteria for License Termination of Uranium Recovery Facilities," of 10 CFR Part 40 outlines the process for applying a benchmark dose. The following paragraph from 10 CFR Part 40, Appendix A, describes the "radium in soil" criterion (Criterion 6[6]):

> *Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more that one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit, will not exceed 1 (unity). A calculation of the peak potential annual TEDE within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site, must be submitted for approval. The use of reclamation plans with benchmark doses which exceed [1 millisievert per year] 100 [millirem per year], before application of as low as is reasonably achievable, requires the approval of the Commission after consideration of the recommendation of NRC staff.*

For the benchmark dose method, the SFC-selected scenario represented a resident farmer with the following radiation exposure pathways (Reclamation Plan, Appendix G, SFC, 2005):

- External exposure from soil.
- Inhalation of suspended soil.
- Ingestion of soil.
- Ingestion of plant products grown in contaminated soil and using potentially contaminated surface water to supply irrigation.
- Ingestion of animal products grown on the site using feed and surface water from potentially contaminated sources.
- Ingestion of fish from potentially contaminated surface water on the site.

SFC indicated that it did not consider two potential exposure pathways:

- **Groundwater usage –** SFC indicated that there are no existing active water wells near or downgradient from the facility that migrating contaminants could affect. The only active wells in the nearby region are either upgradient or so far removed that future impacts are not possible. The shallow aquifers cannot produce sufficient water to qualify as potential drinking water sources or are of such poor quality that the well water would not be suitable for domestic purposes. Because of limited groundwater in this region of Oklahoma, there are extensive potable water distribution systems that use surface-water sources (e.g., Sequoyah County Rural Water District No. 5).

- **Radon inhalation –** SFC indicated that it did not consider radon inhalation because, consistent with EPA guidance, it applied the default DCGLs for radium.

In addition, SFC indicated that it did not consider scenarios that involved inadvertent human intrusion into the disposal cell during the licensed or institutional control periods, with construction of a house with a basement over the waste. SFC eliminated these scenarios because basement construction is not a common feature of homes in northeast Oklahoma. Further, the SFC cell design, including the application of a riprap outer cover over the disposal cell, would prevent human intrusion (Reclamation Plan, Appendix G, SFC, 2005).

In summary, to derive the benchmark dose, SFC applied the resident farmer scenario for the ICB. SFC assumed that this farmer would be exposed to residual radioactivity in surface soil without digging into the disposal cell. During a year, this farmer would spend 25% of the time indoors on the site, 50% of the time outdoors on the site, and 25% of the time away from the site. The contaminated land would produce half of the farmer's entire diet (i.e., vegetables, grain, fruit, milk, and meat). SFC assumed the water source for irrigation and farm animals would be a pond immediately downgradient from the contaminated area. Half of the farmer's aquatic food (fish) diet would be from the pond (Reclamation Plan, Appendix G, SFC, 2005). SFC estimated the resulting dose from radium-226 at the regulatory limit concentration of 0.185 becquerels (5 picocuries) per gram of radium-226 would be 0.54 millisievert (54 millirem) per year. Using the benchmark dose approach, SFC calculated the natural uranium and thorium-230 concentrations in soil that would equal the dose from radium-226 (see Table D-13). SFC would apply these values as DCGLs for soils from the contaminated areas within the ICB. The sum-of-ratios requirement would ensure that the resident farmer dose did not exceed the benchmark dose of 0.54 millisievert (54 millirem) per year for any combination of concentrations of natural uranium, thorium-230, and radium-226. Assuming that this individual resided on the site for 70 years if loss of institutional control of the ICB occurred, the resulting lifetime dose would be about 38 millisievert (3,800 millirem). SFC noted that the value for the natural uranium concentration is high for surface soils for applications outside the ICB. To ensure application of the ALARA principal to the unrestricted areas of the site, SFC developed the CLs in Table D-13.

Applying the same residential farmer scenario to unrestricted areas using the CLs, the natural uranium in the mixture would control the resulting radiation doses because the CLs for thorium-230 and radium-226 are less-than values. The analysis estimated the dose from natural uranium to be about 0.095 millisievert (9.5 millirem) per year by multiplying the ratio of the CL to the DCGL by the benchmark dose. Again, the sum-of-ratios method would ensure that the estimated dose from all three radionuclides was less than or equal to 0.095 millisievert (9.5 millirem) per year. This dose would be less than the public dose limit of 1 millisievert (100 millirem) per year. If this individual resided on the unrestricted area of the site for 70 years, the lifetime dose would be 6.6 millisievert (660 millirem).

Table D-13 DCGLs and CLs

Condition	Natural Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium-226 Bq/g (pCi/g)[a]
DCGL (restricted area)	21 (570)	2.4 (66)	0.18/0.56 (5.0/15)
CL (unrestricted release)	3.7 (100)	≤ 0.52/1.6 (14/≤ 43)	≤ 0.18/0.56 (5.0/15)

Source: SFC, 2005.

[a] As stated in 10 CFR 40, Appendix A, Criterion 6(6), the concentration of radium in the first 15-centimeter (5.9-inch) layer below the surface/followed by the concentration in subsequent 15-centimeter layers more than 15 centimeters below the surface. This criterion is also applied to thorium-230 concentrations.

Both the land within the ICB and in the unrestricted area would contain radionuclide concentrations in surface soil much lower than those in Table D-13. This is because SFC proposes to use clean soil to cover the contaminated areas after moving the contaminated soil to the disposal cell within the ICB. Further, facility operations have left the unrestricted area largely unaffected; therefore, the radionuclide concentrations reflect natural background levels. Therefore, the doses to members of the public following institutional controls estimated for the restricted and unrestricted areas for Alternative 1 are bounding estimates.

Table D-14 lists the estimated individual probabilities of LCFs for the restricted and unrestricted areas for Alternative 1. These estimates use a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) (Eckerman et al., 1999) and an assumed residency time of 70 years. The lifetime risks to the resident farmers in the restricted and unrestricted areas would be low (2.3×10^{-3} and 4.0×10^{-4}, respectively), and the annual doses would be within regulatory limits (the benchmark dose); therefore, the significance level of public radiation exposures and risks after completion of Alternative 1 would be SMALL.

Table D-14 Estimated Probabilities of LCFs for the Resident Farmer Scenario in the Restricted and Unrestricted Areas for Alternative 1

Annual Restricted Area after Loss of Institutional Controls	Lifetime Restricted Area after Loss of Institutional Controls	Annual Unrestricted Area	Lifetime Unrestricted Area
3.2×10^{-5}	2.3×10^{-3}	5.7×10^{-6}	4.0×10^{-4}

D.2.1.4   Alternative 1: Worker Radiation Doses and Risks during Institutional Control

In a manner similar to that used to calculate the DCGLs for the resident farmer scenario, SFC estimated the annual doses to industrial workers during the long-term maintenance and control of the site. These industrial workers, employed or under contract to the long-term custodian, would perform the maintenance tasks, on a limited, part-time basis (i.e., a total of 130 hours per year). The applicable regulatory dose limit to a worker would be 1 millisievert (100 millirem) per year to a member of the public. SFC assumed that the source term would be equivalent to the DCGLs in Table D-13, since this would be the maximum radionuclide concentrations that would be encountered following remediation. The exposure pathways include (Reclamation Plan, Appendix G, SFC, 2005):

- External exposure from soil.
- Inhalation of suspended soil.
- Ingestion of soil.

SFC did not consider additional pathways for the industrial workers because of the nature of their long-term maintenance activities and the limited number of hours worked during a year. These maintenance workers would not be involved in farming activities, use groundwater or surface water since water would be provided by municipal sources, or be exposed to indoor radon since no buildings would be built in the restricted area. SFC assumed the worker would perform maintenance activities within the ICB for a total of 130 hours per year: 32 hours sampling on-site wells and 98 hours mowing (SFC, 2005). The maintenance activities did not include time maintaining the cover since, per the requirements of 10 CFR 40, Appendix A, Criteria 6, site closure requires that reasonable assurance be provided of the control of radiological hazards for 1,000 years, and in any case for at least 200 years. This means that the final cover must be shown to perform without requiring maintenance for at least 200 years, and for up to 1,000 years. The result of the SFC dose assessment was about 0.02 millisievert (2 millirem) per year to this industrial worker. The analysis assumed that the same individual would work at the site for an entire career of 30 years conducting maintenance activities. Although it is unlikely that an individual would perform these activities over an entire 30-year career, it provides a conservative basis for the estimation of lifetime dose to this worker. The resulting lifetime dose would be about 0.6 millisievert (60 millirem). The NRC staff consider these values to be a conservative bounding dose estimate because the land within the ICB would contain radionuclide concentrations in surface soil much lower than those in Table D-13. This is because SFC indicated that it would use clean soil to cover the contaminated areas after moving the contaminated soil to the disposal cell within the ICB. The analysis used a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) (ICRP, 1990) and an assumed residency time of 30 years to estimate the individual annual and lifetime probabilities of LCFs for the restricted area industrial worker under Alternative 1. Table D-15 lists the estimated probabilities of LCFs. The estimated annual probability of an LCF to this industrial worker would be 8×10^{-7}, and the estimated lifetime probability of an LCF would be 2.4×10^{-5}. The estimated risks would be low, and the annual radiation doses would be within the regulatory limit of 1 millisievert (100 millirem) per year; therefore, the significance level of worker radiation exposures and risks during institutional controls would be SMALL.

Table D-15 Estimated Probabilities of LCFs for the Long-term Maintenance Industrial Worker Scenario in the Restricted Areas for Alternative 1

Annual	Lifetime
8×10^{-7}	2.4×10^{-5}

D.2.2 Alternative 2: Off-site Disposal of All Contaminated Materials

Under Alternative 2, SFC would excavate and remove all contaminated soil, sludge, equipment, building rubble, and other contaminated materials from the site and send it to licensed low-level radioactive waste (LLRW) disposal facilities (SFC, 2005). This alternative would not require the construction of an on-site disposal cell. SFC would decontaminate the entire site to meet the CLs in Table D-11. SFC would backfill all excavations, cover them with topsoil, and revegetate them. After completion of reclamation activities, SFC would perform radiation surveys to verify compliance with the CLs before license termination and unrestricted release of the 243-hectare (600-acre) site. There would be no further license or institutional control period.

D.2.2.1 Alternative 2: Off-site Public Radiation Doses and Risks during Reclamation

Off-site public exposures would occur because of the atmospheric release of radionuclides in soil suspended in air. This would occur during the excavation and movement of contaminated soil, building demolition and movement of building rubble, and movement of other materials for off-site disposal. Because the reclamation activities for Alternatives 1 and 2 are similar, the same methods apply to the estimation of off-site radiation exposures during reclamation. As for Alternative 1, off-site air samples served as the basis for estimated public doses during reclamation. The estimated inhalation doses to the MEI would range from 0.003 to 0.005 millisievert (0.3 to 0.5 millirem) per year. These doses would be a small fraction of the 0.25-millisievert-per-year (25-millirem-per-year) public dose limit for site operations, and they are ALARA. For this analysis, 0.005 millisievert (0.5 millirem) per year represented the annual dose to the MEI in the public during reclamation. The lifetime doses the MEI would receive during the four-year reclamation period, assuming constant off-site public doses over this period, would be about 0.02 millisievert (2 millirem) under Alternative 2.

Because radiation dose rapidly decreases with distance downwind because of dispersion of the airborne contaminants, the total collective population dose would be bounded under the assumption that 1,000 individuals would receive the MEI dose. This would equal 0.005 person-sievert (0.5 person-rem) per year. Over the four-year period, the collective dose would be 0.02 person-sievert (2 person-rem) for Alternative 2.

The analysis estimated the probabilities of LCFs for members of the public from Alternative 2, assuming reclamation activities would occur over a four-year period, using a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) for members of the public (Eckerman et al., 1999). Table D-16 lists the estimated probabilities of LCFs to the MEI and the collective population, both for a single year and for the total reclamation period. The estimated total population risks would be low (1.2×10^{-3}) and the annual radiation doses would be within the regulatory limit for the public of 0.25 millisievert (25 millirem) per year; therefore, the significance level of public radiation exposures and risks for reclamation activities for Alternative 2 would be SMALL.

Table D-16 Estimated Probabilities of LCFs for the MEI and the Collective Population for Alternative 2

Individual Annual Risk	Individual Lifetime Risk[a]	Collective Annual Risk	Collective Lifetime Risk[a]
3.0×10^{-7}	1.2×10^{-6}	2.0×10^{-4}	1.2×10^{-3}

[a] Over four years of reclamation activities.

D.2.2.2 Alternative 2: Worker Radiation Doses and Risks During Reclamation

The annual average radiation doses to reclamation workers under Alternative 2 are likely to be the same as those estimated for Alternative 1 because both alternatives would require the relocation of contaminated materials for disposal. The choice of on-site or off-site disposal would not significantly change the expected work conditions, dose rates, or exposure durations for reclamation workers. Only the number of workers and the duration of work would differ.

As listed in Table D-9, the average annual TEDE to workers, based on measured worker doses and intakes from the raffinate sludge dewatering project, would be about 7.47 millisievert (747 millirem) per year. This annual TEDE would bound the annual doses to reclamation workers for Alternative 2 because the average radionuclide concentrations at the site are only about 30% of the concentrations in the raffinate sludge dewatering project. The best estimate of annual worker doses would be 30% of the raffinate sludge dewatering project doses using average radionuclide concentrations, or about 2.2 millisievert (220 millirem) per year. Both the bounding and best-estimate worker annual TEDEs are within the NRC occupational radiation protection standard of 50 millisievert (5 rem) per year. Total doses to a worker during four years of reclamation activities, assuming that the annual average TEDEs remain constant, would result in a worker lifetime TEDE of about 8.8 millisievert (880 millirem).

The analysis estimated worker probabilities of LCFs for Alternative 2, using the radiation worker labor force summarized by quarter and labor category in Table D-17. The resulting estimated TEDEs by quarter and year, and the estimated probabilities of LCFs by year, are shown in Table D-18. The estimated probabilities of LCFs were developed using a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) for industrial workers (ICRP, 1990). Table D-19 summarizes the estimated annual probabilities of LCFs to the average and maximum individual worker, the lifetime probability of an LCF to the average worker, and the collective worker population for the four-year reclamation period. The estimated total worker probabilities of LCFs would be low (1.4×10^{-2}) and the annual worker radiation doses would be within the regulatory limit of 50 millisievert (5 rem) per year; therefore, the significance level of worker radiation exposures and risks for reclamation activities for Alternative 2 would be SMALL.

Table D-17 Radiation Worker Manpower Estimates for Alternative 2

Quarter	H&S Technicians	Equipment Operators	On-Site Truck Drivers	Welders and Riggers	Laborers	Total
1	12	12	8	6	20	58
2	12	12	8	6	20	58
3	12	12	8	6	20	58
4	12	12	8	6	20	58
5	12	12	8	6	20	58
6	12	12	8	6	20	58
7	12	12	8	6	20	58
8	12	12	8	6	20	58
9	6	12	8	0	15	41
10	6	12	8	0	15	41
11	6	12	8	0	10	36

Table D-17 Radiation Worker Manpower Estimates for Alternative 2

Quarter	H&S Technicians	Equipment Operators	On-Site Truck Drivers	Welders and Riggers	Laborers	Total
12	4	3	0	0	10	17
13	4	1	0	0	5	10
14	4	1	0	0	5	10
15	4	1	0	0	5	10
16	4	1	0	0	5	10

Table D-18 Collective Radiation Worker TEDEs and Estimated Probabilities of LCFs for Alternative 1

Quarter/Year	Estimated TEDE person-Sv (person-rem)	Estimated Total Collective Worker Risk
1	0.033 (3.3)	-
2	0.033 (3.3)	-
3	0.033 (3.3)	-
4	0.033 (3.3)	-
Total Year 1	**0.13 (13)**	**5.2×10^{-3}**
5	0.033 (3.3)	-
6	0.033 (3.3)	-
7	0.033 (3.3)	-
8	0.033 (3.3)	-
Total Year 2	**0.13 (13)**	**5.2×10^{-3}**
9	0.022 (2.2)	
10	0.022 (2.2)	
11	0.020 (2.0)	
12	0.0094 (0.94)	
Total Year 3	**0.075 (7.5)**	**3.0×10^{-3}**
13	0.00055 (0.055)	-
14	0.00055 (0.055)	-
15	0.00055 (0.055)	-
16	0.00055 (0.055)	-
Total Year 4	**0.0022 (0.22)**	**8.8×10^{-5}**
Total Over Four Years	**0.34 (34)**	**1.4×10^{-2}**

Table D-19 Estimated Probabilities of LCFs for Reclamation Workers and the Collective Worker Population for Alternative 2

Average Individual Worker Annual Risk	Average Individual Worker Lifetime Risk[a]	Maximum Worker Annual Risk[b]	Total Collective Average Worker[c]
$8.8{\times}10^{-5}$	$3.5{\times}10^{-4}$	$3.0{\times}10^{-4}$	$3.5{\times}10^{-3}$

[a] Over four years of reclamation activities.
[b] Assuming the doses received during the SFC raffinate sludge dewatering project represent the maximum worker doses.
[c] Over the entire radiation worker workforce for four years of reclamation activities.

D.2.2.3 Alternative 2: Long-term Public Radiation Doses and Risks

As discussed in Section D.2.1.3, SFC developed CLs to ensure application of the ALARA principle to the unrestricted areas of the site (SFC, 2005) (see Table D-13 in Section D.2.1.3). Application of the residential farmer scenario to unrestricted areas using the CLs provides radiation doses that are controlled by the natural uranium in the mixture because the CLs for thorium-230 and radium-226 are less-than values. The analysis estimated that the dose from natural uranium would be about 0.095 millisievert (9.5 millirem) per year by multiplying the ratio of the CL to DCGL by the benchmark dose. The sum-of-ratios method ensures that the dose from all three radionuclides would be less than or equal to 0.095 millisievert (9.5 millirem) per year. This dose would be within the current regulatory limit for members of the public of 1 millisievert (100 millirem) per year. If this individual resided on the unrestricted area of the site for 70 years, the lifetime dose would be 6.6 millisievert (660 millirem).

After completion of Alternative 2, the land in the unrestricted area would contain radionuclide concentrations in surface soil much lower than the CLs. This is because SFC proposes to use clean soil to fill and cover the contaminated areas after moving the contaminated soil and other radioactive material off the site for disposal. Further, facility operations have left the majority of the 243-hectare (600-acre) site largely unaffected; therefore, the radionuclide concentrations reflect natural background levels. Therefore, the estimated unrestricted area doses to members of the public of 0.095 millisievert (9.5 millirem) per year after completion of Alternative 2 would bound the potential impacts.

Table D-20 lists the estimated annual and lifetime individual probabilities of LCFs for unrestricted release of the site after completion of Alternative 2. The analysis estimated the probabilities of LCFs using a dose-to-risk conversion factor of $6{\times}10^{-5}$ per millisievert ($6{\times}10^{-7}$ per millirem) (Eckerman et al., 1999) and an assumed residency time of 70 years. The resulting lifetime probability of an LCF to the resident farmer would be low ($4.0{\times}10^{-4}$), and the annual radiation doses would be within the public radiation dose regulatory limits of 1 millisievert (100 millirem) per year; therefore, the significance level of public radiation exposures and risks following completion of Alternative 2 would be SMALL. In addition, there would be no institutional control period for Alternative 2, so there would be no long-term worker doses or risks because unrestricted release would occur immediately upon completion of Alternative 2.

Table D-20 Estimated Probabilities of LCFs for the Resident Farmer Scenario in the Unrestricted Area for Alternative 2

Annual Unrestricted Area	Lifetime Unrestricted Area
5.7×10^{-6}	4.0×10^{-4}

D.2.3 Alternative 3: Partial Off-site Disposal of Contaminated Materials

Under Alternative 3, SFC would excavate and remove selected waste and contaminated materials from the site and send them to licensed LLRW disposal facilities (SFC, 2005). This waste would include some of the more concentrated radioactive sources at the site. SFC would dispose of the remainder of the radioactive material, including soil and other sources that exceed the DCGLs, in an on-site disposal cell similar to that for Alternative 1 (SFC, 1999). The disposal cell would be in the same location but with reduced dimensions and volume to account for the volume of waste shipped off the site. SFC would maintain all of the contaminated areas within a 81-hectare (200-acre) restricted area. The above-grade disposal cell would cover about 4 hectares (10 acres). SFC would consolidate and dispose of all Atomic Energy Act Section 11e.(2) byproduct materials and non-Section 11e.(2) source material wastes, which would remain on the site in this cell. After capping and closure, SFC would establish a fenced ICB around the disposal cell. The ICB would restrict unauthorized access to the area. After capping and closure, SFC would initiate a long-term monitoring plan (SFC, 2005). The design of the engineered disposal cell would comply with NRC performance standards. These standards are outlined in Appendix A of 10 CFR Part 40. SFC would then cover the completed cell surface with riprap to prevent human intrusion. SFC would decontaminate the remainder of the site, the unrestricted area, to meet the CLs in Table D-13. SFC proposes to backfill all excavations, cover them with topsoil, and revegetate them. After completion of reclamation activities, SFC would conduct radiation surveys to verify that the contamination levels did not exceed the CLs. After license termination, SFC would transfer long-term custody of the site to the United States or the State of Oklahoma.

The material that SFC would send off the site for disposal would include the dewatered raffinate sludge, North Ditch sediment, Emergency Basin soil, and Sanitary Lagoon soil. Table D-21 lists the estimated volumes and radionuclide contents of that waste. In comparison with the estimated waste volume in Table D-4, the total on-site disposal volume for Alternative 2 would be about 196,000 cubic meters (256,760 cubic feet).

Table D-21 Off-site Waste Disposal Summary for Alternative 3

Description	Volume m^3 (yd^3)	Natural Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium-226 Bq/g (pCi/g)
Raffinate Sludge	30,129 (39,469)	13-448 (357-12,100)	7.8-604 (211-16,300)	0.22-12.3 (6-332)
North Ditch Sediment	588 (770)	245 (6,618)	86 (2,320)	4.4 (120)
Emergency Basin Soil	413 (541)	104 (2,809)	103 (2,785)	9.1 (245)

Table D-21 Off-site Waste Disposal Summary for Alternative 3

Description	Volume m^3 (yd^3)	Natural Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium-226 Bq/g (pCi/g)
Sanitary Lagoon Soil	294 (385)	338 (9,137)	14 (384)	0.25 (6.7)
Total Volume	**31,424 (41,165)**			

D.2.3.1 Alternative 3: Off-site Public Radiation Doses and Risks during Reclamation

Off-site public exposures would occur because of the atmospheric release of radionuclides in soil suspended in air. This would occur during the excavation and movement of contaminated soil, building demolition and movement of building rubble, and movement of other materials for on- or off-site disposal. Because the reclamation activities for Alternatives 1 and 3 are similar and would involve the same material, the same methods apply to the estimation of off-site radiation exposures during reclamation. This approach uses off-site air sample data that SFC collected during previous reclamation activities at the site. Table D-5 in Section D.2.1.1 summarizes the estimated inhalation radiation doses from data that SFC collected at the nearest residence air sampler for the period from 1995 through 1998 (SFC, 2005). The NRC staff considers this location to be the location of the MEI in the public. The estimated inhalation doses range from 0.003 to 0.005 millisievert (0.3 to 0.5 millirem) per year. These doses are a small fraction of the 0.25-millisievert (25-millirem)-per-year public dose limit for site operations and are considered to be ALARA. This analysis used 0.005 millisievert (0.5 millirem) per year to represent the annual dose to the MEI in the public during reclamation. For comparison, an average individual living in Oklahoma receives a radiation dose of about 3.6 millisievert (360 millirem) per year from all sources (NCRP, 1987). The lifetime doses the MEI would receive during the four-year reclamation period, assuming constant off-site public doses over this period, would be about 0.02 millisievert (2 millirem) under Alternative 3.

Because radiation dose rapidly decreases with distance downwind because of dispersion of the airborne contaminants, the assumption that 1,000 individuals would receive the MEI dose would bound the total collective population dose. This would equal 0.005 person-sievert (0.5 person-rem) per year. Again, assuming that reclamation activities would occur over a four-year period, the collective dose would be 0.02 person-sievert (2 person-rem) for Alternative 3.

The analysis estimated the probabilities of LCFs for members of the public for Alternative 3, assuming reclamation activities would occur over a four-year period, using a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) for members of the public (Eckerman et al., 1999). Table D-22 lists the probabilities of LCFs to the MEI and the collective population both for a single year and for the total reclamation period. The estimated total population risks would be low (1.2×10^{-3}), and the annual radiation doses would be within the regulatory limit for the public of 0.25 millisievert (25 millirem) per year; therefore, the significance level of public radiation exposures and risks for reclamation activities for Alternative 3 would be SMALL.

Table D-22 Estimated Probabilities of LCFs for the MEI and the Collective Population during Reclamation for Alternative 3

Individual Annual Risk	Individual Lifetime Risk[a]	Collective Annual Risk	Collective Lifetime Risk[a]
3.0×10^{-7}	1.2×10^{-6}	3.0×10^{-4}	1.2×10^{-3}

[a] Over four years of reclamation activities.

D.2.3.2 Alternative 3: Worker Radiation Doses and Risks During Reclamation

The estimated annual average radiation doses to reclamation workers for Alternative 3 are likely to be the same as those for Alternative 1. This is because both alternatives require demolition of buildings and excavation of soil with the relocation of the contaminated materials for disposal. Disposal off the site would not significantly reduce the dose to reclamation workers because the same reclamation activities would occur up to the point of disposal. Only the number of workers and the duration of work would differ.

As listed in Table D-9, the analysis estimated the average annual TEDE to a worker, based on measured worker doses and intakes from the raffinate sludge dewatering project, would be 7.47 millisievert (747 millirem) per year. This annual TEDE would bound the annual doses to reclamation workers for Alternative 3 because the average radionuclide concentrations at the site are only about 30% of the concentrations in the raffinate sludge dewatering project. The best estimate of annual worker doses would be 30% of the raffinate sludge dewatering project doses using average radionuclide concentrations, or about 2.2 millisievert (220 millirem) per year. Both the bounding and best-estimate worker annual TEDEs would be within the NRC occupational radiation protection standard of 50 millisievert (5 rem) per year. Total doses to a worker during four years of reclamation activities, assuming that the annual average TEDEs remain constant, would result in an average worker lifetime TEDE of about 8.8 millisievert (880 millirem).

The analysis estimated the total collective dose to the workforce and the probabilities of LCFs to that workforce for Alternative 3 using the radiation worker labor force summarized by quarter and labor category in Table D-23. The resulting estimated TEDEs by quarter and year, and the estimated probabilities of LCFs by year, are shown in Table D-24. The estimated probabilities of LCFs were developed using a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) for industrial workers (ICRP, 1990). Table D-25 summarizes the estimated probability of an LCF to the average and maximum individual worker, the lifetime probability of an LCF to the average worker, and the collective worker population for the total reclamation period. The total estimated average worker probability of an LCF would be low (1.4×10^{-2}), and the annual worker radiation doses would be within the regulatory limit of 50 millisievert (5 rem) per year; therefore, the significance level of worker radiation exposures and risks for reclamation activities for Alternative 3 would be SMALL.

Table D-23 Radiation Worker Manpower Estimates for Alternative 3

Quarter	Cell Closure	H&S Technicians	Equipment Operators	On-Site Truck Drivers	Welders and Riggers	Laborers	Total
1	0	11	8	8	6	29	62
2	0	11	8	8	6	29	62
3	0	11	8	8	6	29	62
4	0	11	8	8	6	29	62
5	0	11	8	8	6	29	62
6	0	11	8	8	6	29	62
7	0	11	8	8	6	29	62
8	0	11	8	8	6	29	62
9	0	4	3	3	0	15	25
10	8	4	3	3	0	15	25
11	8	4	3	3	0	10	20
12	0	4	3	3	0	10	20
13	0	4	1	1	0	5	11
14	0	4	1	1	0	5	11
15	0	4	1	1	0	5	11
16	0	4	1	1	0	5	11

Table D-24 Collective Radiation Worker TEDEs and Estimated Probabilities of LCFs for Alternative 3

Quarter/Year	Estimated TEDE person-Sv (person-rem)	Estimated Total Collective Worker Risk
1	0.034 (3.4)	-
2	0.034 (3.4)	-
3	0.034 (3.4)	-
4	0.034 (3.4)	-
Total Year 1	**0.14 (14)**	**5.6×10^{-3}**
5	0.034 (3.4)	-
6	0.034 (3.4)	-
7	0.034 (3.4)	-
8	0.034 (3.4)	-
Total Year 2	**0.14 (14)**	**5.6×10^{-3}**
9	0.013 (1.3)	
10	0.013 (1.3)	
11	0.011 (1.1)	
12	0.011 (1.1)	
Total Year 3	**0.048 (4.8)**	**1.9×10^{-3}**
13	0.0060 (0.6)	-
14	0.0060 (0.6)	-
15	0.0060 (0.6)	-
16	0.0060 (0.6)	-
Total Year 4	**0.024 (2.4)**	**9.6×10^{-4}**
Total Over Four Years	**0.35 (35)**	**1.4×10^{-2}**

Table D-25 Estimated Probabilities of LCFs for Reclamation Workers and the Collective Worker Population for Alternative 3

Average Individual Worker Annual Risk	Average Individual Worker Lifetime Risk[a]	Maximum Worker Annual Risk[b]	Total Collective Average Worker[c]
8.8×10^{-5}	3.5×10^{-4}	3.0×10^{-4}	1.4×10^{-2}

[a] Over four years of reclamation activities.
[b] Assuming the doses received during the SFC raffinate sludge dewatering project represent the maximum worker doses.
[c] Over the entire radiation worker workforce during four years of reclamation activities.

D.2.3.3 Alternative 3: Long-term Public Radiation Doses and Risks

As discussed in Section D.2.1.3, SFC developed DCGLs for the restricted area and CLs for the unrestricted area of the site (see Table D-13 in Section D.2.1.3). The analysis used application of the DCGLs and CLs based on the residential farmer scenario to restricted and unrestricted areas as the basis for the radiation dose estimates for Alternative 3. Because partial off-site disposal would still leave a significant inventory in the ICB, and because the residual soil contamination cleanup within the ICB would be the same for Alternatives 1 and 3, the long-term radiation dose and probability of LCF estimates would be the same for both alternatives. The DCGLs would apply to soils from the contaminated areas within the ICB. The sum-of-ratios requirement would ensure that the resident farmer dose would not exceed 0.54 millisievert (54 millirem) per year for any combination of concentrations of natural uranium, thorium-230, and radium-226. If this individual resided at the site for 70 years after loss of institutional control of the ICB, the resulting lifetime dose would be 37.8 millisievert (3,780 millirem).

The NRC staff determined that the residential farmer scenario applied to unrestricted areas using the CLs would result in radiation doses controlled by the natural uranium in the mixture because the CLs for thorium-230 and radium-226 are less-than values. The analysis estimated the dose from natural uranium by multiplying the ratio of the CL to DCGL by the benchmark dose; the dose would be about 0.095 millisievert (9.5 millirem) per year. The sum-of-ratios method would ensure that the dose from all three radionuclides would be less than or equal to 0.095 millisievert (9.5 millirem) per year. This dose would be less than the public radiation dose limit of 1 millisievert (100 millirem) per year. If this individual resided on the unrestricted area of the site for 70 years, the resulting lifetime dose would be 6.6 millisievert (660 millirem).

The NRC staff noted that both the land within the ICB and in the unrestricted area would contain radionuclide concentrations in surface soil much lower than those in Table D-13. This is because SFC proposes to use clean soil to cover the contaminated areas after moving the contaminated soil to the disposal cell within the ICB. Further, facility operations have left the unrestricted area largely unaffected; therefore, the radionuclide concentrations reflect natural background levels. Therefore, the estimated doses to members of the public after lapse of institutional controls for the restricted and unrestricted areas for Alternative 3 would bound the impacts.

Table D-26 lists the individual probabilities of LCFs for the restricted and unrestricted areas for Alternative 3. These estimates use a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) (Eckerman et al., 1999) and an assumed residency time of 70 years.

Table D-26 Estimated Probabilities of LCFs for the Resident Farmer Scenario in the Restricted and Unrestricted Areas for Alternative 3

Annual Restricted Area Following Loss of Institutional Controls	Lifetime Restricted Area Following Loss of Institutional Controls	Annual Unrestricted Area	Lifetime Unrestricted Area
3.2×10^{-5}	2.3×10^{-3}	5.7×10^{-6}	4.0×10^{-4}

The estimated lifetime risks would be low (2.3×10^{-3} and 4.0×10^{-4}), and the annual radiation doses would be within the regulatory limit of 1 millisievert (100 millirem) per year; therefore, the significance level of public radiation exposures and risks after completion of Alternative 3 would be SMALL.

D.2.3.4 Alternative 3: Worker Radiation Doses and Risks during Institutional Control

In a manner similar to that for the DCGLs for the resident farmer scenario (see Section D.2.1.3), SFC estimated annual doses to an industrial worker during the long-term maintenance and control of the site. Because Alternatives 1 and 3 would require the same long-term maintenance and surveillance activities, the estimated radiation doses and LCFs to the workers would be the same. The analysis assumed an industrial worker employed or under contract to the long-term custodian would perform the maintenance tasks for a total of 130 hours per year (32 hours sampling on-site wells and 96 hours mowing). The applicable annual regulatory dose limit would be 1 millisievert (100 millirem) per year to a member of the public. The resulting SFC dose assessment would be about 0.02 millisievert (2 millirem) per year to this industrial worker. Assuming that this individual worked at the site for 30 years conducting maintenance activities, the resulting lifetime dose would be about 0.6 millisievert (60 millirem). The NRC staff considers these values to be conservative bounding dose estimates because the land within the ICB would contain radionuclide concentrations in surface soil much lower than those in Table D-13. This is because SFC proposes to use clean soil to cover the contaminated areas after moving the contaminated soil to the disposal cell within the ICB. The analysis estimated the individual annual and lifetime probabilities of LCFs for the restricted area industrial worker under Alternative 3 using a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) (ICRP, 1990) and an assumed residency time of 30 years. Table D-27 lists the estimated probabilities of LCFs. The estimated annual probability of an LCF to this industrial worker would be 8×10^{-7}, and the estimated lifetime probability of an LCF would be 2.4×10^{-5}. The estimated risks would be low, and the annual radiation doses would be within the annual regulatory limits of 1 millisievert (100 millirem) per year; therefore, the significance level of worker radiation exposures and risks during institutional controls would be SMALL.

Table D-27 Estimated Probabilities of LCFs for the Long-term Maintenance Industrial Worker Scenario in the Restricted Areas for Alternative 3

Annual	Lifetime
8.0×10^{-7}	2.4×10^{-5}

D.2.4 No-Action Alternative

The no-action alternative would retain the site in its current configuration. There would be no additional processing or stabilization of radioactivity and no decontamination of buildings or land. All on-site buildings and waste materials would remain in their current condition and configuration. Under this alternative, the NRC would not terminate SFC's source material license but would require SFC to maintain a portion of the 81-hectare (200-acre) industrial area indefinitely under restricted conditions. The site would not undergo cleanup and reclamation in accordance with 10 CFR Part 40, Appendix A. SFC would take corrective measures in the event of degradation of containment structures, release of contaminated materials, or intrusion. Over the long term, NRC would require SFC to perform surveillance and maintenance to ensure safe conditions and control of contaminated materials.

D.2.4.1 No-Action Alternative: Off-site Public Radiation Doses and Risks

For the no-action alternative, the estimated off-site public exposures would be minimal (far less than those from active reclamation) because there would be no processing or stabilization of radioactive material. If conditions deteriorated such that environmental releases of radioactivity could occur, NRC would require SFC to take corrective measures. There would be no atmospheric release of radionuclides in soil suspended in air or facility effluents. Therefore, this analysis did not estimate off-site public doses or risks for the no-action alternative.

D.2.4.2 No-Action Alternative: Worker Radiation Doses and Risks

Under the no-action alternative, trained radiation workers employed by or under contract to SFC would conduct routine maintenance and surveillance tasks during the continuing license phase. Worker radiation doses would be similar to those observed historically at the SFC site. Table D-28 lists the annual occupational TEDEs for SFC employees for the period from 1995 through 2004 (SFC, 2005; Table 4-5). The annual TEDE would account for radiation from external sources as well as internal sources that resulted from inhalation of airborne radioactive material. As listed in Table D-28, the average worker TEDE would be 0.27 millisievert (27 millirem rem) per year. This analysis assumed that average annual worker doses would continue for as long as SFC maintained the license. The analysis assumed that the maximum annual worker dose would be the highest average value in Table D-28 – 1.2 millisievert (120 millirem) per year. These doses are well within the NRC occupational radiation protection standard of 50 millisievert (5 rem) per year. SFC estimates that it would take seven workers to perform continuing maintenance and surveillance activities under the no-action alternative (SFC, 2005; Section 2.1.1). The analysis estimated lifetime doses to these workers by assuming that each worker would spend 30 years employed at the site under continuing license conditions. The lifetime TEDE to the average worker would be 8.0 millisievert (800 millirem), and the lifetime TEDE to the maximally exposed worker would be 36 millisievert (3,600 millirem). The estimated annual collective TEDE to the seven workers would be 0.002 person-sievert (0.20 person-rem) per year, and the lifetime collective dose (assuming all seven workers spent 30 years at the site) would be 0.056 person-sievert (5.6 person-rem). Table D-29 summarizes these occupational doses. The analysis did not estimate collective doses over the license continuation period because the length of the continuing licensing period is indeterminate.

Table D-28 Measured Occupational Dose for Sequoyah Fuels Corporation

Year	Number of Individuals in Each Range: Less than Measurable	0 to 1 mSv/yr (0 to 100 mrem/yr)	1 to 2.5 mSv/yr (100 to 250 mrem/yr)	>2.5 mSv/yr (>250 mrem/yr)	Average Dose (TEDE) mSv/yr (mrem/yr)
1995	34	18	0	0	0.14 (14)
1996	7	3	0	1	1.19 (119)
1997	7	3	4	0	0.16 (16)
1998	8	17	1	0	0.27 (27)
1999	15	7	0	0	0.23 (23)
2000	1	4	0	0	0.04 (4)
2001	0	5	0	0	0.28 (28)
2002	1	4	0	0	0.21 (21)
2003	3	3	0	0	0.16 (16)
2004	6	0	0	0	0
Overall Average Dose					**0.27(27)**

Table D-29 Estimated Worker Radiation Doses for the No-Action Alternative

Dose Receptor	Individual Annual Dose mSv/yr (mrem/yr)	Individual Lifetime Dose mSv/yr (mrem)	Collective Annual Dose person-sievert/yr (person-rem/yr)	Collective Lifetime Dose person-sievert (person-rem)
Average Worker Doses during License Continuation	0.27 (27)	8.0 (800)	0.002 (0.20)	0.056 (5.6)
Maximum Worker Doses during License Continuation	1.2 (120)	36 (3,600)	N/A	N/A

The analysis estimated individual annual and lifetime probabilities of LCFs for the industrial workers under the no-action alternative using a dose-to-risk conversion factor of 4×10^{-5} per millisievert (4×10^{-7} per millirem) (ICRP, 1990) and an assumed employment time of 30 years. Table D-30 lists the estimated probabilities of LCFs. The estimated annual probability of an LCF to the average industrial worker would be 1.1×10^{-5}, and the estimated lifetime probability of an LCF would be 3.3×10^{-4}. The annual and lifetime probabilities of an LCF to the maximally exposed worker would be 4.8×10^{-5} and 1.4×10^{-3}, respectively. The estimated risks would be low, and the annual radiation doses would be within the regulatory limit of 50 millisievert (5 rem) per year; therefore, the significance level of worker radiation exposures and risks during institutional controls would be SMALL.

Table D-30 Estimated Probabilities of LCFs to Workers for the No-Action Alternative

Dose Receptor	Individual Annual Risk	Individual Lifetime Risk
Average Worker Risks during License Continuation	1.1×10^{-5}	3.3×10^{-4}
Maximum Worker Risks during License Continuation	4.8×10^{-5}	1.4×10^{-3}

D.2.4.3 No-Action Alternative: Long-term Public Doses after Loss of License Controls

Because of the long half-lives of the radionuclides at the SFC facility and site, it may be possible that at some point in the future the license conditions could lapse. In this event, members of the public could have access to the site, which could result in the resident farmer scenario described for Alternative 1. SFC derived CLs and DCGLs for the site (see Section D.2.1.3) without consideration of any institutional controls and solely in relation to the dose from pathways that relate to residual radioactive materials in surface soil. SFC developed the derivation of DCGLs based on a radiation exposure scenario analysis using the RESRAD computer program (Yu et. al., 2001) and applying the benchmark dose approach. The DCGLs served as the starting point for the analysis of public doses and risks for the no-action alternative. The DCGLs represent an MEI dose of 0.54 millisievert (54 millirem) per year for each of natural uranium, thorium-230, and radium-226. For alternatives involving the remediation or decontamination of soil, the sum-of-ratios approach would limit the dose for any mixture to 0.54 millisievert (54 millirem) per year. For the no-action alternative, however, the doses to the MEI would not be limited to 0.54 millisievert (54 millirem) per year because no remediation or decontamination would occur. The analysis estimated the MEI dose by dividing the existing contamination concentrations for each radionuclide by the appropriate DCGL (to determine how much in the residual contamination would be in excess of the DCGLs), multiplied that result by the benchmark dose of 0.54 millisievert (54 millirem) per year, then summed over the radionuclides. Because it is not possible to determine the condition of the residual radioactive contamination when the license conditions could lapse, the analysis made two estimates: (1) doses based on the average soil concentrations, and (2) doses based on the maximum soil concentrations. Table D-31 lists the average and maximum soil contamination concentrations, summarizes them, and provides the sum of ratios to the DCGLs for the three radionuclides.

Table D-31 Average and Maximum Soil Concentrations Used in the No-Action Alternative Public Dose Evaluation

Contamination Level	Natural Uranium Bq/g (pCi/g)	Thorium-230 Bq/g (pCi/g)	Radium-226 Bq/g (pCi/g)	Sum of Ratios to DCGLs[a]
Average Site	72 (1,940)	76 (2,063)	2.6 (71)	49
Maximum (Contaminated Area 2, Clarifiers)	221 (5,978)	756 (20,400)	12 (317)	383

[a] The sum of the ratio of the radionuclide concentration to the DCGL, summed over each radionuclide.

The analysis estimated the MEI dose for the average and maximum contamination levels by multiplying the sum of ratios in Table D-31 by the benchmark dose of 0.54 millisievert (54 millirem) per year. The resulting MEI doses would be about 26 millisievert (2,600 millirem) per year for the average soil concentration and 210 millisievert (21,000 millirem) per year for the maximum soil concentration. These doses are far in excess of the 1-millisievert-per-year (100-millirem-per-year) dose limit for members of the public. The estimated lifetime doses, assuming 70 years of site occupancy, would be about 1,800 millisievert (180,000 millirem) for the average soil concentration condition, and 14,000 millisievert (1,400,000 millirem) for the maximum soil concentration condition.

Table D-32 lists the estimated individual probabilities of LCFs for the no-action alternative. These estimates use a dose-to-risk conversion factor of 6×10^{-5} per millisievert (6×10^{-7} per millirem) (Eckerman et al., 1999) and an assumed residency time of 70 years.

Table D-32 Estimated Probabilities of LCFs for the Public Radiation Risks for the No-Action Alternative after License Conditions Lapse

Contamination Level	Individual Annual Risk	Individual Lifetime Risk
Average Contamination Level Risks to the Public	1.6×10^{-3}	1.1×10^{-1}
Maximum Contamination Level Risks to the Public	1.2×10^{-2}	8.7×10^{-1}

The estimated lifetime probability of an LCF for the average soil concentration would be 1.1×10^{-1}, and that for the maximum soil concentration would be 8.7×10^{-1}. The estimated probabilities of LCFs would be more significant than for the other alternatives and, for the maximum soil concentration, they would be more likely than not to result in an LCF (a probability greater than 0.5). Further, the annual radiation doses would be far in excess of the regulatory limit of 1 millisievert (100 millirem) per year; therefore, the significance level of public radiation exposures and risks for the no-action alternative would be HIGH.

D.3 Screening Level Risk Analysis for Chemicals

A screening-level risk analysis was performed in order to assess potential adverse health effects associated with chemical (nonradiological) contamination in soils and sediments at the SFC site. Soil and sediment data from previously conducted investigations were compared to background soil concentrations and human health-based, medium-specific screening levels for residential use. Data presented in the following reports serves as the basis for this comparison:

- *Sequoyah Fuels Corporation Site Characterization Report* (SFC, 1998);
- *Sequoyah Fuels Corporation Facility Environmental Investigation Findings Report*, Volumes 1-5 (SFC, 1991);
- *Sequoyah Fuels Corporation Final RCRA Facility Investigation Report* (SFC, 1996).

Soil data from these reports were compared to EPA Region 6 Human Health Medium-Specific Screening Levels for residential use (EPA, 2007a). The Region 6 values consider exposure via incidental ingestion of soil, dermal contact with soil, and inhalation of soil particulates. These values were developed using equations from EPA guidance and commonly used EPA default exposure factors. Toxicity information and other chemical factors used to develop screening levels are published by the EPA or academic sources. The Region 6 soil screening values (EPA, 2007a) are based on a noncancer hazard index of 1 and a total excess cancer risk of 1E-06 (1 in a million, or 1×10^{-6}). If the concentrations of nonradiological contaminants at a site do not exceed the applicable screening levels, there would be no expectation of adverse health effects resulting from exposure to site contamination screened using this method. Table D-33 below presents the screening values used for this assessment.

Table D-33 EPA Region 6 Human Health Medium-Specific Screening Levels

Analytes	Residential Soil Screening Level (mg/kg)
Aluminum	7.6E+04
Antimony and compounds	3.1E+01
Arsenic (cancer endpoint)	3.9E-01
Barium and compounds	1.6E+04
Beryllium and compounds	1.5E+02
Cadmium and compounds	3.9E+01
Total Chromium (1/6 ratio Cr VI/Cr III)	2.1E+02
Cobalt	9.0E+02
Copper and compounds	2.9E+03
Fluoride	3.7E+03
Iron	5.5E+04
Lead	4.0E+02
Lithium	1.6E+03
Manganese and compounds	3.2E+03
Mercury and compounds	2.3E+01
Molybdenum	3.9E+02
Nickel and compounds	1.6E+03
Nitrate[a]	1.3E+05
Selenium	3.9E+02
Silver and compounds	3.9E+02
Strontium, stable	4.7E+04
Thallium	5.5E+00
Vanadium	3.9E+02
Zinc	2.3E+04

[a] Region 6 does not publish a value for nitrate in soil. This value is the Region 3 Risk-Based Screening Level for residential exposure (EPA, 2007b).

In addition to comparing site data to Region 6 screening values, concentrations of chemicals detected in soils and sediment were compared to background concentrations. A soil background evaluation was conducted as part of the Sequoyah Fuels Corporation RCRA Facility Investigation (RFI; SFC, 1996) In summary, background soil samples were collected from four off-site locations within 8 kilometers (5 miles) of the SFC facility. The background soil sample locations were selected to represent the three main soil series that are encountered in the Industrial Area. Sample locations were selected such that anthropogenic influences were minimized. Drainage ways, paved surfaces, railroads, and agricultural (cropland) areas were avoided. At three of the four background locations, soil samples were collected from three boreholes, which were approximately 30.5 meters (100 feet) apart in a triangular pattern. Samples from two profiles from each of the three boreholes were collected and composited for analyses. The fourth background sample was collected from a single location. Each borehole was advanced to a maximum depth of 1.2 meters (4 feet). The background concentrations of metals that were analyzed during the RFI are provided in Table D-34. From the results presented in the RFI, SFC determined there were no apparent differences in metals concentrations for the various soil series sampled. Therefore, all background soil samples were grouped together for determination of background soil concentrations (SFC, 1996). Background sample analytical results were compiled for each parameter, and calculations were performed to determine the mean and standard deviations. The RFI established a “prediction interval” for each metal at the 99% confidence level. The upper prediction interval is the arithmetic mean plus three standard deviations. The results of this statistical analysis are presented in Table 3.4-3.

Table D-34 Background Concentrations of Metals

Analyte	Background Value (mg/kg)
Aluminum	16,760
Antimony	10
Arsenic	39.8
Barium	188.4
Beryllium	1.6
Cadmium	8.1
Chromium	33.5
Cobalt	21.5
Copper	23.1
Lead	32.7
Lithium	12.7
Manganese	718
Mercury	0.044
Molybdenum	1.2
Nickel	21.5
Selenium	10
Silver	0.6
Strontium	27.9
Thallium	24.3
Vanadium	44.1
Zinc	58

Source: SCF, 1996.

Background concentrations for fluoride and nitrate in soils are presented in the *Sequoyah Fuels Corporation Site Characterization Report* (SCR; SFC, 1998). The SCR states that a total of 31 background locations outside of the facility were sampled. However, the emphasis of the background investigation presented in the SCR was the characterization of background conditions for radiological components. Data presented in Table 6 of the SCR indicates that nitrate analysis was performed on four of the 31 background samples collected. The concentration of nitrate detected ranged from 3 to 7 mg/kg. Data presented in Table 6 of the SCR indicate that fluoride analysis was performed on two background samples. Fluoride concentrations of 134 mg/kg and 146 mg/kg were detected in these samples.

Screening was not performed for essential elements such as calcium, iron, potassium, magnesium, and sodium. Detected concentrations of these elements on the site were well below levels of concern.

Table D-35 presents the sample location, depth, and coordinates of all the sample locations that exceed either EPA Region 6 Human Health Medium-Specific Screening Levels for residential use (EPA, 2007a) or established background concentrations for metals (SFC, 1996) or for fluoride and nitrate (SFC, 1998). Figure 4.4-1 in Chapter 4 identifies the locations of samples in which exceedances were detected.

Table D-35 shows that fluoride levels in soil and sediment exceed background and Region 6 health-based screening criteria at many locations throughout the site. Exceedances of Region 6 health-based screening criteria and background levels also were noted for arsenic (five locations), lead (three locations), antimony (two locations), and lithium, molybdenum, nickel, vanadium, copper, and chromium (one location each).

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
BH093	MW-89A, NORTHWEST OF FL.SLDGE HLDG BASIN NO2 BH-93	2835978.9	196905.1	Fluoride	7,480	20.00	to	22.00	3/15/1991
				Fluoride	21,400	22.00	to	24.00	3/15/1991
				Fluoride	10,000	24.00	to	26.00	3/15/1991
BH148	NORTHWEST OF ADU/MISC DIGESTION BUILDING	2836727.1	195728.6	Antimony	43	0.00	to	2.00	3/22/1995
BH208	NORTH OF COOLING TOWER, SC-234	2836824.2	196065.9	Fluoride	5,850	0.00	to	0.50	4/8/1991
BH209	NORTH OF COOLING TOWER, SC-235	2836884.4	196062.5	Fluoride	6,000	0.00	to	0.50	4/4/1991
BH230	SX-8, NORTH EAST CORNER OF SX YARD, C-8	2836764.4	195934.2	Fluoride	10,834	2.50	to	3.00	3/11/1991
				Fluoride	11,097	3.50	to	3.90	3/11/1991
BH267	EAST WEST TRENCH NORTH OF SX, Top 6", SX-18	2836806.2	195644.8	Fluoride	7,020	0.00	to	0.50	3/6/1991
BH268	EAST WEST TRENCH	2836806.2	195644.8	Fluoride	5,010	1.50	to	2.00	3/6/1991

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
	NORTH OF SX, Top 6", SX-19								
HA208	POND 2 HOLE10	2835603	195521.5	Fluoride	3,750	0.00	to	0.50	7/18/1991
				Fluoride	7,490	1.50	to	2.00	7/18/1991
HA316	NORTHWEST CORNER OF LIME NEUT SILO NEAR VENT	2836630	195820	Fluoride	9,230	0.00	to	0.50	11/16/1995
SD001	N0RTHWEST QUADRANT OF POND 4	2836609	193971	Fluoride	32,400	0.00	to	15.00	3/24/1994
SD002	N0RTHEAST QUADRANT OF POND 4	2836749	193971	Fluoride	9,370	0.00	to	15.00	3/24/1994
SD003	SOUTHWEST QUADRANT OF POND 4	2836638	193804	Fluoride	25,200	0.00	to	15.00	3/24/1994
SD004	SOUTHEAST QUADRANT OF POND 4	2836735	193790	Fluoride	25,500	0.00	to	15.00	3/24/1994
SD013	FLUORIDE SLUDGE-SOUTHWEST AREA	2835951	195044	Arsenic	133	0.00	to	10.00	1/24/1995
				Fluoride	34,300	0.00	to	10.00	1/24/1995
SD014	COMPOSITE FROM 4 QUADRANTS	2836096	195772	Arsenic	1,350	0.00	to	10.00	1/25/1995

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
	OF CLARIFIER 1A								
				Chromium	259	0.00	to	10.00	1/25/1995
				Fluoride	34,200	0.00	to	10.00	1/25/1995
				Lead	515	0.00	to	10.00	1/25/1995
				Molybdenum	556	0.00	to	10.00	1/25/1995
				Vanadium	3,950	0.00	to	10.00	1/25/1995
SD017	COMPOSITE FROM 3 SECTIONS OF NORTH DITCH	2836786	196158	Fluoride	10,300	0.00	to	4.00	2/1/1995
SD018	COMPOSITE FROM 3 SECTIONS OF EMERGENCY BASIN	2836559	196226	Antimony	117	0.00	to	0.50	2/1/1995
				Arsenic	98	0.00	to	0.50	2/1/1995
				Fluoride	3,930	0.00	to	0.50	2/1/1995
SD019	COMPOSITE FROM 3 SECTIONS OF SANITARY LAGOON	2836554	195941	Arsenic	440	0.00	to	0.60	2/1/1995
				Lead	555	0.00	to	0.60	2/1/1995
SD024	EMERGENCY BASIN, EMERGENCY BASIN #1, SC 131	2836535.8	196370.1	Fluoride	8,140	0.00	to	0.50	4/11/1991

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
SD025	EMERGENCY BASIN, EMERGENCY BASIN #2, SC 172	2836520.8	196219.5	Fluoride	9,880	0.00	to	0.50	4/11/1991
SD026	EMERGENCY BASIN, EMERGENCY BASIN #3, SC 189	2836642.4	196173.6	Fluoride	7,040	0.00	to	0.50	4/11/1991
SD061	FLUORIDE HOLDING BASIN #1 (SOUTH)– EAST END	2836202	194894	Fluoride	27,700	0.00	to	10.00	9/28/1995
SD062	FLUORIDE HOLDING BASIN #1 (SOUTH)– WEST END	2836072	194894	Fluoride	22,100	0.00	to	10.00	9/28/1995
SD063	FLUORIDE HOLDING BASIN #2 (NORTH)– EAST END	2836213	196778	Fluoride	11,200	0.00	to	10.00	9/28/1995
SD064	FLUORIDE HOLDING BASIN #2 (NORTH)– WEST END	2836106	196728	Fluoride	39,600	0.00	to	10.00	9/28/1995

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
SD066	FLUORIDE SETTLING BASIN #2 (SOUTH)– WEST END	2836207	195232	Fluoride	17,400	0.00	to	10.00	9/28/1995
SD067	FLUORIDE SETTLING BASIN #1 (NORTH)– EAST END	2835961	195275	Fluoride	14,700	0.00	to	10.00	9/28/1995
SD068	FLUORIDE SETTLING BASIN #1 (NORTH)– WEST END	2836057	195299	Fluoride	50,800	0.00	to	10.00	9/28/1995
SD069	FLUORIDE CLARIFIER– WEST END	2835826	195266	Fluoride	23,300	0.00	to	0.50	9/28/1995
SD070	FLUORIDE CLARIFIER– EAST END	2835995	195275	Fluoride	8,740	0.00	to	0.50	9/28/1995
SD186	SANATARY LAGOON NORTH WEST 1/4	2836468	195984	Fluoride	5,160	0.00	to	0.50	10/17/1995
SD188	CLARIFIER 2A NORTH EAST	2836014	195635	Fluoride	24,400	0.00	to	10.00	10/16/1995
SD189	CLARIFIER 2A NORTH WEST	2836177	195642	Fluoride	31,900	0.00	to	10.00	10/16/1995

Table D-35 Sample Locations Exceeding Screening Criteria

Sample ID	Location Description	Easting	Northing	Analyte	Concentration (mg/kg)	Sample Depth (feet)			Sample Date
SD190	CLARIFIER 2A SOUTH EAST	2836012	195497	Fluoride	19,500	0.00	to	10.00	10/16/1995
SD191	CLARIFIER 2A SOUTH WEST	2836165	195497	Fluoride	29,000	0.00	to	10.00	10/16/1995
SD195	NORTH DITCH SOUTH EAST 1/4	2836874	196104	Fluoride	14,800	0.00	to	4.00	10/17/1995

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APPENDIX E

TRANSPORTATION ANALYSIS:

METHODOLOGY, ASSUMPTIONS, AND IMPACTS

E.1 Introduction and Background

This appendix documents the assumptions, input data, methods, results, and references used in the evaluation of potential transportation impacts associated with the shipment off site of contaminated materials during decommissioning activities at the Sequoyah Fuels Corporation (SFC) facility. The analysis focused on the radiological and nonradiological human health impacts associated with the shipment of up to 142,000 cubic meters (5 million cubic feet) of contaminated materials. The analysis evaluated projected shipments of materials from the SFC facility in Gore, Oklahoma, to three potential disposal sites in Utah and New Mexico (see Section 2.4.1).

Section E.2 provides (1) contaminated material inventories for each material type, (2) assumptions made regarding shipping configurations (e.g., package characteristics for truck and rail shipments), (3) package radiological characteristics (e.g., radiological constituent concentrations and radiation dose rates), and (4) the routing assumptions for shipments to disposal facilities. Section E.3 presents the assumptions, methods, and computer codes used to evaluate potential impacts from the incident-free transport of contaminated materials and lists the detailed impact estimates. Section E.4 presents the assumptions, methods, and computer codes used to evaluate impacts from potential transportation accidents and lists the results for the maximum reasonably foreseeable radiological accident as well as fatalities from vehicle emissions and traffic accidents. Section E.5 summarizes transportation-related human health impacts. Section E.6 lists the references for the analyses.

E.2 Disposal Information

This section describes the information used to evaluate radiological and nonradiological transportation impacts. The U.S. Nuclear Regulatory Commission (NRC) provided most of the information; however, if specific information was unavailable, conservative assumptions were used to provide reasonable assurance that impacts would not be underestimated. Section E.2.1 describes the disposal inventories by type for all materials that SFC would ship off site under Alternative 2 (Off-site Disposal of All Contaminated Materials) and Alternative 3 (Partial Off-site Disposal of Contaminated Materials. Section E.2.2 describes the shipping configurations, including the volumes that SFC would ship off site under these alternatives. Section E.2.3 provides routing information, including affected populations along the route to the disposal site.

E.2.1 Inventory

Evaluation of transportation impacts requires knowledge of the current and projected contaminated material inventory at the SFC facility. Table E-1 provides the inventories evaluated for each material type.

E.2.2 Shipping Configurations

The transportation impact analysis evaluated potential radiological and nonradiological impacts on transportation workers and members of the public from incident-free (i.e., routine) transportation as well as the postulated maximum reasonably foreseeable radiological transportation accident. Potential radiological impacts from incident-free transportation would depend upon, among other things, the level of penetrating radiation that emanated from the complete shipping package, which includes 53-foot truck vans and gondola railcars, the total number of shipments by mode (i.e., truck and rail), and the distance of each shipment. The analysis used the MicroShield® program (Grove Engineering, 1998) to calculate the radiation dose rates based on the package radionuclide content, overall size of the package (i.e., length, height, and depth), density of the material, and the amount of shielding material (e.g., the thickness of the gondola and truck van side walls). The analysis assumed that, under Alternative 2 (Off-site Disposal of All Contaminated Materials), the contaminated materials would be shipped off-site using rail gondola cars. Under this alternative, all contaminated materials would be shipped as bulk except for the raffinate sludge and the sediments from the Emergency Basin, North Ditch, and Sanitary Lagoon, which would be shipped in super sacks (see below for description).

Under Alternative 3 (Partial Off-site Disposal of Contaminated Materials), the analysis assumed that only the raffinate sludge and the sediments from the Emergency Basin, North Ditch, and Sanitary Lagoon would be shipped off-site in super sacks using trucks. The distance for each shipment would depend on the destination; however, because SFC expects to ship most of the material to the Energy Solutions facility in Clive, Utah, and because this facility involves the longest travel distance, the assumption that all contaminated materials would be transported to the Clive, Utah, facility provided an upper bound of potential transportation impacts.

To simplify, the analysis assumed that truck shipments would consist of 18 supersacks with a total weight of about 18,000 kilograms (kg) (39,600 pounds) of contaminated material transported in standard 53foot enclosed truck vans and that rail shipments would be in typical gondola railcars about 16.5 meters (54 feet) long. Table E-1 summarizes the number of rail and truck shipments for Alternatives 2 and 3, respectively.

This analysis used a dose rate of 1 milliroentgen per hour at a distance of 1 meter (3.3 feet) from the vehicle to generate unit dose factors. To produce material-specific results, the analysis modified these unit dose rate factors by the estimated dose rates from each radionuclide mixture and for each shipment mode (i.e., truck and rail). The analysis used the MicroShield® computer program (Grove Engineering, 1998) to calculate the dose rates for specific contaminated material mixtures for each type of shipping container, as discussed in Section E.3.1.2. Table E-2 lists the specific radionuclide mixtures for each contaminated material.

Table E-1 Contaminated Material Volume and Weight and Numbers of Truck and Rail Shipments

Description	Disposal Volume (cubic feet)[a]	Total Weight (g)	Alternative 2 All Off-site Disposal	Alternative 3 Partial Off-site Disposal
			No. of Railcars[b]	No. of Trucks[c]
Sludges and Sediments				
Raffinate Sludge[d,e]	247,009	9.51E+09	97	529
Pond 2 Residual Materials[d]	762,000	3.69E+10	305	NA
Emergency Basin Sediment[d]	14,600	6.25E+08	6	35
North Ditch Sediment[d]	20,770	8.89E+08	9	49

Table E-1 Contaminated Material Volume and Weight and Numbers of Truck and Rail Shipments

Description	Disposal Volume (cubic feet)[a]	Total Weight (g)	Alternative 2 All Off-site Disposal	Alternative 3 Partial Off-site Disposal
			No. of Railcars[b]	No. of Trucks[c]
Sanitary Lagoon Sediment[d]	10,365	4.44E+08	5	25
Fluoride Holding Basin No. 1	171,400	7.48E+09	69	NA
Fluoride Holding Basin No. 2	186,000	8.11E+09	74	NA
Fluoride Settling Basins and Clarifier	114,300	4.98E+09	46	NA
Buried Calcium Fluoride	96,380	4.20E+09	39	NA
Buried Fluoride Holding Basin No. 1	57,200	2.49E+09	23	NA
Liner Soils and Subsoils				
Clarifier Liners	332,400	1.66E+10	133	NA
Calcium Fluoride Basin Liner	95,285	4.75E+09	38	NA
Emergency Basin Soils	162,500	8.10E+09	65	NA
North Ditch Soils	87,500	4.36E+09	35	NA
Sanitary Lagoon Liner	56,356	2.81E+09	23	NA
Buried Material/Drums				
Pond 1 Spoils Pile	437,400	2.18E+10	175	NA
Interim Storage Cell	154,887	7.72E+09	62	NA
Solid Waste Burials (No. 1)	43,000	2.14E+09	17	NA
Solid Waste Burials (No. 2)	8,100	4.04E+08	3	NA
DUF_4 Drummed Container Trash	2,200	3.40E+07	1	NA
Other Drummed Container Trash	5,000	7.72E+07	2	NA
Empty Contaminated Drum	2,000	5.00E+07	1	NA
Structural Materials[f]				
Main Process Building	436,600	3.96E+10	397	NA
Solvent Extraction Building	36,000	3.27E+09	33	NA
DUF_4 Building	56,200	5.10E+09	51	NA
ADU/Misc Digestion Building	2,500	2.27E+08	2	NA
Laundry Building	3,000	2.72E+08	3	NA
Centrifuge Building	6,000	5.44E+08	5	NA
Bechtel Building	5,400	4.90E+08	5	NA
Solid Waste Building	3,600	3.27E+08	3	NA
Cooling Tower	6,000	5.44E+08	5	NA
RCC Evaporator	3,750	3.40E+08	3	NA
Incinerator	1,500	1.36E+08	1	NA

Table E-1 Contaminated Material Volume and Weight and Numbers of Truck and Rail Shipments

Description	Disposal Volume (cubic feet)[a]	Total Weight (g)	Alternative 2 All Off-site Disposal	Alternative 3 Partial Off-site Disposal
			No. of Railcars[b]	No. of Trucks[c]
Concrete and Asphalt	511,795	4.64E+10	465	NA
Contaminated material	50,000	1.25E+09	45	NA
Chipped Pallets	3,000	2.55E+07	1	NA
Subsoils and Bedrock				
Contaminated Materials	3,574,000[g]	1.78E+11	1,430	NA
TOTALS	7,456,470	4.21E+11	3,678	638

[a] To convert to cubic meters, multiply by 0.02832.

[b] Railcars assumed to be typical 16.46-meter (54-foot) gondolas with a 71-cubic-meter (2,500-cubic-foot) capacity and a corrugated effective wall thickness of 0.48 centimeter (0.1875 inch). Railcars are assumed to carry 108 super sacks.

[c] Trucks assumed to be typical truck vans, 53 feet long, loaded with 18 super sacks and with 12 guage sheet metal frames (wall thickness of 0.272 centimeter [0.1072 inch]), with 0.635 centimeter (0.25 inch) plywood on the sides and 1.905 centimeter (0.75 inch) plywood on the front.

[d] Assumed to be shipped off-site under Alternative 3.

[e] For shipping calculations, assumed that the raffinate sludge is LSA-II and is shipped in IP-2 packaging (i.e., super sacks) as per 39 CFR 173.427.

[f] Structural materials, because of their high density, are weight limited to 99,880 kilograms (220,000 pounds), or 31.2 cubic meters (1,100 cubic feet).

[g] Represents estimated quantity of soil to be excavated under Alternative 2 only. This is the only alternative that applies to off-site shipment by rail.

NA = Not Applicable

Table E-2 Radionuclide Quantities for Truck and Rail Shipments

Description	Curies[a] per Truck					Curies[a] per Railcar				
	U-234	U-235	U-238	Ra-226	Th-230	U-234	U-235	U-238	Ra-226	Th-230
Sludges and Sediments										
Raffinate Sludge	2.96E-02	1.39E-03	2.91E-02	1.91E-03	4.52E-01	1.61E-01	7.60E-03	1.59E-01	1.04E-02	2.46E+00
Pond 2 Residual Materials	NA	NA	NA	NA	NA	1.78E-02	8.37E-04	1.75E-02	5.25E-03	1.57E-01
Emergency Basin Sediment	7.81E-03	3.67E-04	7.67E-03	3.45E-03	1.35E-01	4.26E-02	2.00E-03	4.18E-02	1.88E-02	7.38E-01
North Ditch Sediment	7.81E-03	3.68E-04	7.67E-03	6.07E-04	2.02E-03	4.26E-02	2.00E-03	4.18E-02	3.31E-03	1.10E-02
Sanitary Lagoon Sediment	2.60E-02	1.23E-03	2.56E-02	4.05E-04	2.03E-02	1.42E-01	6.69E-03	1.40E-01	2.21E-03	1.11E-01
Fluoride Holding Basin No. 1	NA	NA	NA	NA	NA	6.01E-03	2.83E-04	5.90E-03	2.92E-05	1.90E-04
Fluoride Holding Basin No. 2	NA	NA	NA	NA	NA	6.89E-03	3.24E-04	6.76E-03	2.69E-05	1.88E-04
Fluoride Settling Basins and Clarifier	NA	NA	NA	NA	NA	1.00E-02	4.73E-04	9.87E-03	2.19E-05	1.75E-04
Buried Calcium Fluoride	NA	NA	NA	NA	NA	1.98E-02	9.32E-04	1.94E-02	1.56E-04	6.23E-04
Buried Fluoride Holding Basin No. 1	NA	NA	NA	NA	NA	5.94E-03	2.80E-04	5.84E-03	4.37E-05	1.75E-04
Liner Soils and Subsoils										
Clarifier Liners	NA	NA	NA	NA	NA	1.76E-03	8.30E-05	1.73E-03	7.52E-05	9.03E-03
Calcium Fluoride Basin Liner	NA	NA	NA	NA	NA	1.01E-03	4.74E-05	9.89E-04	NIL	NIL
Emergency Basin Soils	NA	NA	NA	NA	NA	7.21E-03	3.40E-04	7.09E-03	NIL	NIL
North Ditch Soils	NA	NA	NA	NA	NA	5.15E-03	2.42E-04	5.05E-03	NIL	NIL
Sanitary Lagoon Liner	NA	NA	NA	NA	NA	2.11E-03	9.95E-05	2.08E-03	NIL	NIL
Buried Material/Drums										
Pond 1 Spoils Pile	NA	NA	NA	NA	NA	3.02E-04	1.42E-05	2.97E-04	2.86E-04	5.72E-03
Interim Storage Cell	NA	NA	NA	NA	NA	2.35E-02	1.11E-03	2.31E-02	NIL	NIL
Solid Waste Burials	NA	NA	NA	NA	NA	1.85E-02	8.70E-04	1.82E-02	NIL	NIL

Table E-2 Radionuclide Quantities for Truck and Rail Shipments

Description	Curies[a] per Truck					Curies[a] per Railcar				
	U-234	U-235	U-238	Ra-226	Th-230	U-234	U-235	U-238	Ra-226	Th-230
(No. 1)										
Solid Waste Burials (No. 2)	NA	NA	NA	NA	NA	6.23E-03	2.93E-04	6.12E-03	NIL	NIL
DUF_4 Drummed Container Trash	NA	NA	NA	NA	NA	3.94E-01	7.73E-03	3.89E-01	NIL	NIL
Other Drummed Container Trash	NA	NA	NA	NA	NA	3.70E-03	1.74E-04	3.64E-03	NIL	NIL
Empty Contaminated Drum	NA	NA	NA	NA	NA	9.26E-03	4.36E-04	9.09E-03	NIL	NIL
Structural Materials										
Main Process Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Solvent Extraction Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
DUF_4 Building	NA	NA	NA	NA	NA	8.40E-03	1.65E-04	8.29E-03	NIL	NIL
ADU/Misc Digestion Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Laundry Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Centrifuge Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Bechtel Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Solid Waste Building	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Cooling Tower	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
RCC Evaporator	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Incinerator	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Concrete and Asphalt	NA	NA	NA	NA	NA	8.40E-03	3.96E-04	8.25E-03	NIL	NIL
Contaminated material	NA	NA	NA	NA	NA	1.68E-03	7.91E-05	1.65E-03	NIL	NIL
Chipped Pallets	NA	NA	NA	NA	NA	NIL	NIL	NIL	NIL	NIL
Subsoils and Bedrock										
Contaminated Materials	NA	NA	NA	NA	NA	7.42E-03	3.49E-04	7.28E-03	NIL	NIL

[a] To convert to becquerels, multiply by 3.7E10.

E.2.3 Routing

To assess the impacts of radioactive materials transportation, the analysis first had to define the characteristics of transportation routes between the origin of the shipments and their destinations. These route characteristics are values such as distance, exposed populations, and weighted population densities. This type of analysis often divides population density into three zones–rural, suburban, and urban–where rural is defined as an area with a density of less than about 54 people per square kilometer (139 people per square mile), suburban is defined as an area with a density between 54 and about 1,284 people per square kilometer (139 and 3,326 people per square mile), and urban is defined as an area with a density greater than 1,284 people per square kilometer (3,326 people per square mile) (Johnson and Michelhaugh, 2003). The analysis typically estimates the distance traveled within each population zone along with the total distance.

For shipments from the SFC site to a low-level radioactive waste disposal site (assumed to be Clive, Utah), the analysis used the WebTRAGIS computer program (Johnson and Michelhaugh, 2003) and 2000 Census data to examine the highway and rail routes. Route characteristics include total shipment distance between the SFC site and Clive, Utah; the distances traveled in rural, suburban, and urban population density zones; and the weighted population densities in these zones.

SFC considered the following potential off-site disposal locations for the dewatered raffinate sludge and sediments (SFC, 2005):

- Energy Solutions in Clive, Utah, is 2,190 truck kilometers (1,361 miles) from the SFC facility.
- The International Uranium Corporation’s White Mesa Mill in Blanding, Utah, is 1,607 truck kilometers (998.5 miles) from the facility.
- Waste Control Specialists near Andrews, Texas, is 1,038 truck kilometers (645 miles) from the facility.

The analysis chose routes by minimizing the total impedance of each route, which is a function of distance and driving time between the origin and destination. WebTRAGIS can identify routes that maximize the use of interstate highways. This analysis used the commercial route setting to generate highway routes that commercial trucks generally use. While these might not be the actual routes that SFC would use, their application in the analysis provides best estimates of the potential impacts. The producers of WebTRAGIS periodically update the highway function to reflect current road conditions. The analysis used the population summary module of WebTRAGIS to determine the exposed populations within 800 meters (0.5 mile) of either side of the route.

The analysis also used WebTRAGIS to simulate routing for rail shipments. The WebTRAGIS database describes the U.S. railroad system and includes all rail lines except industrial spurs, and it includes inland and intracoastal waterways and deep-water routes. The database contains more than 15,000 rail and barge segments known as links (although this analysis does not include barging) and more than 13,000 stations, interchange points, ports, and other locations known as nodes. As with the highway function, the rail function of WebTRAGIS includes nodes for NRC- and Agreement State-licensed facilities and DOE nuclear facilities. For the railroad routes, the origin was a node (402117507) near the SFC facility, and the destination nodes were near Clive and Blanding, Utah, and Andrews, Texas. Table E-3 summarizes the distance and population density data for this analysis for truck and rail shipments.

Table E-3 Distance and Exposed Populations within 800 Meters of Truck and Rail Routes[a]

	Kilometers[a]			Persons per Square Kilometer[b]			Totals	
	Rural	Suburban	Urban	Rural	Suburban	Urban	Kilometers[a]	Affected Population
Truck								
Clive, Utah	1,209	134.0	18.2	7.9	315.2	2,174	2,190	146,168
Blanding, Utah	1,401	180.6	25.9	7.0	318.9	2,296	1,607	202,987
Andrews, Texas	859.8	157.6	20.4	9.2	349.8	2.228	1,038	100,935
Rail								
Clive, Utah	2,118	257.3	49.4	6.5	421.5	2,195	2,424	369,043
Blanding, Utah	1,809	259.8	37.9	6.7	398.8	2,166	2,107	316,512
Andrews, Texas	976.1	219.3	26.5	8.8	425.9	2,067	1,221	250,824

[a] To convert to miles, multiply by 0.62137

[b] To convert to persons per square mile, multiply by 2.57.

The producers of WebTRAGIS periodically update the rail function to reflect mergers, abandonments, and current track conditions and to benchmark reported mileage and observations of commercial rail firms.

Because SFC has not determined the actual disposal site for all materials, the analysis and the detailed discussion in the following sections are limited to shipments to Clive, Utah, the longest route. Although, this assumption maximizes all of the potential rail impacts, some of the impacts from truck shipments (e.g., latent cancer fatalities in exposed populations) could be higher for shipments to Blanding, Utah. A comparison of all potential impacts for each of the possible disposal sites is provided in Section E.5.3, Tables E-27 through E-29.

E.3 Incident-Free Transportation

This section discusses the calculation of potential radiological exposures from shipments of contaminated material off the site. Such shipments can emit some ionizing radiation through the shipping container during routine, incident-free transportation. Persons exposed to this radiation would receive an external radiation dose. The exposed population would include truck and train crews, rail yard workers, and members of the public.

Section E.3.1 provides an overview of the methods and assumptions used to calculate collective doses, including the estimated doses, and Section E.3.2 describes the methods and assumptions used to calculate doses to individuals. Section E.3.3 discusses the determination of vehicle emission unit risk factors and their use in estimating potential nonradiological impacts.

E.3.1 Incident-Free Collective Dose

Figure E-1 shows the flow of information through RADTRAN 5 and the Sequoyah RiskModel, which were used to estimate radiation doses to receptors.

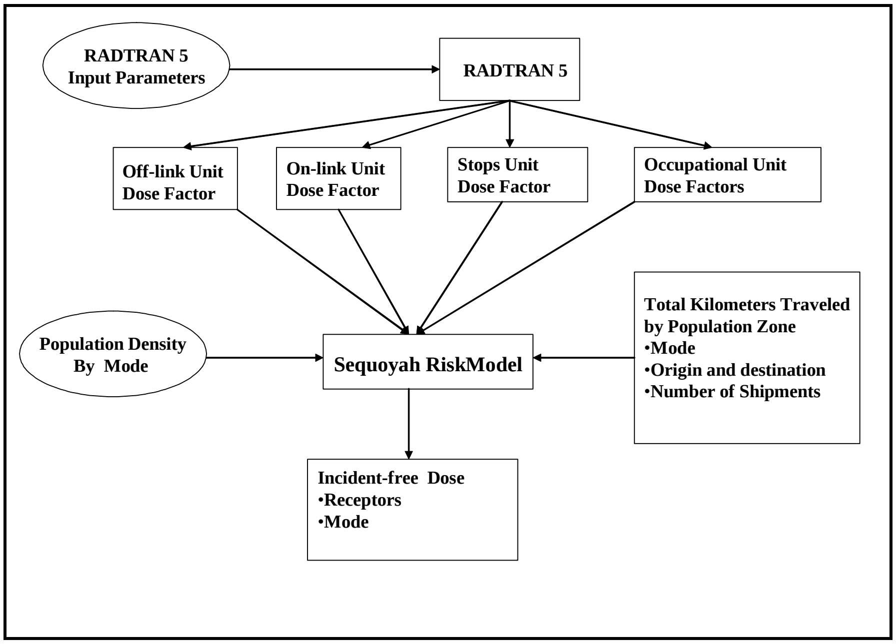

Figure E-1 Information Flow for Calculation of Collective Doses from Incident-Free Transportation

The analysis calculated incident-free collective doses under the assumption that the external dose rate from the shipping package would be the radiation source that exposed receptors at various distances from the package. The MicroShield® computer program (Grove Engineering, 1998) calculated the radiation exposure from the shipping package based on the radionuclide content of the package. The analysis then used a combination of these estimated exposure rates at 1 meter (3.3 feet; referred to as transport indexes, or TIs), RADTRAN 5, and the Sequoyah RiskModel to calculate the doses. The analysis considered exposures from moving and stationary vehicles. RADTRAN 5 calculates incident-free doses to the highest exposed member of the public, to workers (except truck drivers), and members of the general public ("public doses"). The analysis performed separate calculations for the following receptors:

- The *off-link* population dose applies to members of the general public who resided or were pedestrians along the transportation routes and who were exposed by moving railcars and trucks.

- The *on-link* population dose applies to occupants of motor vehicles or trains that shared the transportation route with the shipment while it was moving.

- The *resident rest stop* dose applies to members of the public who lived within 800 meters (0.5 mile) of a rest stop area where a truck stopped for crew rest or refueling. This dose applies only for truck shipments.

- The *crew dose* applies to truck crew members when a truck was moving. This dose is only for truck shipments.
- The *truck driver* dose applies to individuals driving trucks who were 1.5 meters (4.9 feet) from the end of the shipping package. This dose is only for truck shipments.
- The *truck stop* population dose applies to members of the public who were at rest and refueling stops when a truck carrying the shipment stopped for crew rest or refueling. This dose is only for truck shipments.
- The *maximally exposed resident along route* dose applies to a member of the public who lived within 30 meters (98 feet) of a truck or rail route who was exposed to in-transit shipments (both rail and truck shipments).
- The *maximally exposed resident at stop* dose applies to a member of the public who lived within 30 meters (98 feet) of locations where trucks or rail shipments stopped (for rest/refuel, classification, etc.).
- The *rail workers at classification stop* dose applies to rail yard workers, crew, and inspectors who loaded and organized (classified) and inspected trains at both the origin and destination of each rail shipment. This dose is only for rail shipments.
- The *distance-dependent rail worker* dose applies to rail yard workers at in-transit rail stops along the route. This dose is only for rail shipments.

The incident-free dose to a receptor is an external dose and depends on the dose rate external to the package. These external dose rates, or TIs, are a function of the radionuclide mix, metal type, and package type; the analysis used conservative assumptions for the estimations to maximize the calculated doses to provide reasonable assurance that incident-free doses would not be underestimated.

E.3.1.1 Assumptions

The model used to calculate collective population incident-free doses incorporates several general assumptions that apply to both transportation modes. The calculated doses are directly proportional to the number of shipments that move past the receptor (Neuhauser, 2000). The collective incident-free population dose is proportional to the number of receptors. For truck and rail transportation-related exposures, the assumed receptors occupy an 800-meter (0.5-mile) -wide corridor on either side of the route, and the population density in each corridor reflects the population density of the census block group that abuts or contains the route. Section E.2.3 discusses population assumptions and calculations.

The following sections describe the assumptions and parameters the analysis used with RADTRAN 5 to calculate off- and on-link doses. RADTRAN 5 includes a table of standard parameter values, as well as suggested values for other parameters. This section provides the input parameters for calculating collective and individual doses from a moving truck and doses to individuals and nearby populations when the truck stops for refueling and crew rest.

Parameters and Assumptions for Doses from Moving Trucks. Table E-4 lists the assumptions and input parameters, including national average traffic counts, used to calculate incident-free doses from moving truck shipments. The model assumes freeway truck speeds are constant in the absence of rush-hour traffic. Vehicles sharing the route would provide no shielding from the shipping package external radiation. However, buildings in suburban and urban areas would have shielding factors of 0.87 and 0.018, respectively. The model used national average one-way vehicle speeds to calculate the on-link dose for national truck shipments. The following receptors were evaluated along the modeled route in the incident-free truck transportation analysis:

- Members of the public who reside along the route and pedestrians (off-link).
- Occupants of vehicles that share the route (on-link).
- Crew dose (truck drivers).

Table E-4 Assumptions and Parameters for Incident-Free Doses from Moving Trucks

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	8.23 meters[a]	Length of package
Dose rate	Assumed to be 1 millirad per hour for calculation of unit dose factors	Actual values used for dose estimations
Fraction of emitted radiation that is gamma	1	
Fraction of emitted radiation that is neutrons	0	
Crew		
Number of crew	2	Analytical assumption
Distance from source to crew	1.5 meters[a]	Neuhauser, 2000
Route-specific parameters		
Rural	88.49 kilometers per hour[b]	Neuhauser, 2000
Suburban	40.25 kilometers per hour	Neuhauser, 2000
Urban	24.16 kilometers per hour	Neuhauser, 2000
Number of people per vehicle sharing route	2	
One-way traffic volumes		
Rural	283 vehicles per hour	Neuhauser, 2000
Suburban	590 vehicles per hour	Neuhauser, 2000
Urban	1,575 vehicles per hour	Neuhauser, 2000
Minimum and maximum distances to exposed resident off-link population	30 to 800 meters[a]	Neuhauser, 2000

Table E-4 Assumptions and Parameters for Incident-Free Doses from Moving Trucks

Parameter	Parameter Value	Comments and Reference
Population densities[c] (persons per square kilometer)[d]		
Rural	(b)	
Suburban	(b)	

[a] To convert meters to feet, multiply by 3.2808.
[b] To convert kilometers to miles, multiply by 0.62137.
[c] Population densities along transportation routes from WebTRAGIS using 2000 Census data. See Table E-3.
[d] To convert to persons per square mile, multiply by 2.57.

Parameters and Assumptions for Calculating Truck Stop Doses. Section E.3.1.3 describes the rest and refueling stop model. Stop doses are proportional to the exposure time; they are inversely proportional to the distance to nearby receptors and to the square of the distance for distant receptors. Residences near stops would provide no shielding. The receptors at modeled stops in the incident-free truck transportation analysis are:

- Members of the public at rest and refueling stops (e.g., truck stops).
- Residents of the area in the vicinity of the truck stops.

Table E-5 lists the assumptions about package type and dimensions, external dose rate, and ratio of gamma to neutron radiation (this analysis assumed all radiation is gamma, so the gamma-to-neutron fraction is 1).

Table E-5 Assumptions and Parameters for Incident-Free Doses at Truck Stops

Parameter	Parameter Value	Comments and Reference
Members of the public at truck stops		
Area of public exposure at the truck stop	Annulus of inner radius 1 meter[a], outer radius 20 meters[a]	DOE, 2002a
Number of members of the public exposed at the truck stop	25	This is entered in RADTRAN 5 as 19,900 persons per square kilometer (DOE, 2002a)
Area of public exposure: residents near the truck stop	30 to 800 meters[a] from source	Neuhauser, 2000
Crew		
Crew members exposed at truck stops	2	Analytical assumption
Crew distance to package	2 meters[a]	Analytical assumption
Stop time	1.69 hours (104 minutes)[b]	DOE, 2002a
Distance between stops	1,206 kilometers[c]	Sprung et al., 2000

[a] To convert meters to feet, multiply by 3.2808.
[b] Assumes distance-dependant stop time of 0.0014 hours per kilometer.
[c] To convert kilometers to miles, multiply by 0.62137.

Parameters and Assumptions for Doses from a Moving Railcar. Table E-6 lists the assumptions used to calculate incident-free doses from moving rail shipments.

Table E-6 Assumptions and Parameters for Incident-Free Doses of Moving Railcars

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	16.46 meters[a]	Length of rail gondola
Dose rate	Assumed to be 1 millirad per hour for calculation of unit dose factors.	Actual values used for dose estimators.
Fraction of emitted radiation that is gamma	1	
Fraction of emitted radiation that is neutrons	0	
Route parameters		
Speed		
Rural	64 kilometers per hour[b]	Neuhauser, 2000
Suburban	40.25 kilometers per hour	Neuhauser, 2000
Urban	24 kilometers per hour	Neuhauser, 2000
Number of people per vehicle sharing route	3	Neuhauser, 2000
Minimum and maximum distances to exposed resident off-link population	30 meters to 800 meters[a]	Neuhauser, 2000
Population densities (persons per square kilometer)[c]		
Rural	(c)	
Suburban	(c)	
Urban	(c)	
One-way traffic count (vehicles per hour) on national highways		
Rural	1	Neuhauser, 2000
Suburban	5	Neuhauser, 2000
Urban	5	Neuhauser, 2000
Crew	--	Crew assumed to be too distant and too well-shielded from external radiation from the cargo when the train is moving.

[a] To convert meters to feet, multiply by 3.2808.
[b] To convert kilometers to miles, multiply by 0.62137.
[c] Population densities along transportation routes from WebTRAGIS using 2000 Census data. See Table E-3.

Parameters and Assumptions for Doses from a Stopped Railcar. The receptors at modeled rail stops in the incident-free analysis are:

- Residents of the areas near all stops.
- Rail crew and rail yard workers at classification stops and in-transit stops.

Table E-6 lists the assumptions about package type and package dimensions, external dose rate, and the ratio of gamma to neutron radiation. Tables E-7 and E-8 summarize additional assumptions used to calculate potential doses to populations at terminal and in-transit rail stops, respectively.

Table E-7 Assumptions and Parameters for Incident-Free Doses from Rail Terminal/Classification Stops

Parameter	Parameter Value	Comments and Reference
Occupational classification stop dose		
Terminal classification stop dose	From Neuhauser, 2000, Appendix B	Neuhauser, 2000 calculates an occupational dose for a classification stop based on the dimensions and external dose rate of the shipping package. This dose is embedded in RADTRAN 5.
Terminal classification stop time	30 hours	Neuhauser, 2000
Number of terminal classification stops per trip	One	For unit dose factor calculation. Neuhauser, 2000
Residents near terminal classification stops		
Stop in suburban area	(a, b)	
Area of public exposure	400 to 800 meters from source[c]	RISKIND: Neuhauser and Kanipe, 2000
Maximally exposed resident at stop		
Stop time	30 hours	Neuhauser, 2000
Distance to resident	400 meters[c]	Neuhauser, 2000

[a] Population densities along transportation routes from WebTRAGIS using 2000 Census data. See Table E-3.
[b] Classification stops would be in rural or suburban areas.
[c] To convert meters to feet, multiply by 3.2808.

Table E-8 Assumptions and Parameters for Incident-Free Doses from In-Transit Rail Stops

Parameter	Parameter Values	Comments and Reference
Occupational dose		
In-transit classification stop dose	From Neuhauser, 2000, Appendix B	Neuhauser, 2000 calculates an occupational dose for an in-transit classification stop based on the dimensions and external dose rate of the shipping package. This dose is embedded in RADTRAN 5.
Distance-dependent worker exposure factor	0.0018 per kilometer[a]	According to Neuhauser, 2000, the in-transit classification stop occupational dose is multiplied by a distance-dependent worker exposure factor to estimate the occupational dose at in-transit stops.
Residents near in-transit stops		
Stop time	(b)	Neuhauser, 2000
Distance between stops	555 kilometers	Neuhauser, 2000
Stop in rural area	(c)	
Stop in suburban area	(c)	
Stop in urban area	(c)	
Area of public exposure	30 to 800 meters[d]	Exposure distance on either side of the route.

Table E-8 Assumptions and Parameters for Incident-Free Doses from In-Transit Rail Stops

Parameter	Parameter Values	Comments and Reference
		Neuhauser, 2000
Maximally exposed resident at stop		
Stop time	10 hours	Analytical assumption
Distance to resident	30 meters[d]	Neuhauser, 2000

[a] To convert kilometers to miles, multiply by 0.62137.
[b] Embedded in RADTRAN – not user defined.
[c] Population densities along transportation routes from WebTRAGIS using 2000 Census data. See Table E-3.
[d] To convert meters to feet, multiply by 3.2808.

The Sequoyah RiskModel provides RADTRAN 5 input and output files for the calculation of unit dose factors. The RiskModel also includes the values for route segment lengths, population densities, and numbers of shipments from the SFC site to disposal facilities (see Section E.2). The RADTRAN 5 calculation includes all other factors in the calculation of the appropriate unit dose factor. Therefore:

- The off-link unit dose factor is per shipment, per kilometer, per unit population density (persons per square kilometer), per millirem, and per hour (package TI). The off-link dose is then the product of this unit dose factor multiplied by the number of shipments and the appropriate combination of route distance and population density.

- The on-link unit dose factor is per shipment, per kilometer, per millirem, and per hour. The on-link dose is then the product of this unit dose factor multiplied by the number of shipments and the appropriate route distance (*not* the population density).

The unit dose factors do not include the number of shipments, but Table E-1 lists those for the contaminated material type and alternative. Tables E-9 and E-10 list the per-shipment unit dose factors for incident-free truck and rail transportation, respectively. In addition to the other multiplying factors in the tables, the Sequoyah RiskModel multiplies these unit dose factors by the number of shipments appropriate for each alternative. Tables E-11 and E-12 list the public and worker population doses, by alternative, for the entire shipping campaign, including doses to maximally exposed individuals (MEIs). The Sequoyah RiskModel contains a more detailed presentation of consequences (i.e., dose) and calculated risks (latent cancer fatalities, or LCFs) (see Section E.5).

The analysis used RADTRAN 5 to calculate radiological unit dose factors, which were entered into the Sequoyah RiskModel to calculate collective incident-free population doses. The *RADTRAN 5 Technical Manual* (Neuhauser, 2000) and *RADTRAN 5 User Guide* (Neuhauser and Kanipe, 2000) provide detailed descriptions of the theoretical bases and application of this program.

E.3.1.2 Analysis of Doses from Moving Vehicles

This section briefly describes the RADTRAN 5 model and deals only with specific details of the application of RADTRAN 5 in the moving-vehicle analysis. The analysis used a dose rate of 0.1 millisievert (1 millirem) per hour at a distance of 1 meter (3.3 feet) from the vehicle to generate

Table E-9 Per-Shipment Unit Dose Factors, Units, and Multipliers for Incident-Free Truck Transportation

Receptor	Value	Units[a]	Multiply by
Public		**person-millisievert per external dose rate per**	**external dose rate × …**
Off-link rural	4.02E-08	unit population density per kilometer	rural population density × rural kilometers
Off-link suburban	8.80E-08	unit population density per kilometer	suburban population density × suburban kilometers
Off-link urban	1.47E-07	unit population density per kilometer	urban population density × rural kilometers
On-link rural	5.96E-06	per kilometer	rural kilometers
On-link suburban	6.24E-05	per kilometer	suburban kilometers
On-link urban	4.90E-04	per kilometer	urban kilometers
Residents near rural stop	2.65E-09[b]	unit population density per kilometer	rural population density × rural kilometers
Residents near suburban stop	2.65E-09[b]	unit population density per kilometer	suburban population density × suburban kilometers
Residents near urban stop	2.65E-09[b]	unit population density per kilometer	urban population density × rural kilometers
Public at rural highway rest/refuel stops	2.07E-05[b]	per kilometer	rural kilometers
Public at suburban highway rest/refuel stops	2.07E-05[b]	per kilometer	suburban kilometers
Public at urban highway rest/refuel stops	207E-05[b]	per kilometer	urban kilometers
Workers		**person-millisievert per external dose rate per**	**external dose rate × …**
Truck crew rural rest/refuel	5.78E-05[b]	per kilometer	rural kilometers
Truck crew suburban rest/refuel	5.78E-05[b]	per kilometer	suburban kilometers
Truck crew urban rest/refuel	5.78E-05[b]	per kilometer	urban kilometers
Truck crew rural in-transit	4.07E-04	per kilometer	rural kilometers
Truck crew suburban in-transit	8.90E-04	per kilometer	suburban kilometers
truck crew urban in-transit	1.48E-03	per kilometer	urban kilometers
Highest exposed public individual			**external dose rate × …**
Resident closest to the route	6.51E-07	rem per external dose rate per trip	total trips
Resident near stop	2.65E-07	rem per external dose rate per kilometer	total kilometers

Source: Sequoyah RiskModel; see Section E.5 for details.
[a] To convert kilometers to miles, multiply by 0.62137.
[b] RADTRAN 5 output for single stop divided by 1,206 kilometers (725 miles) per stop.

Table E-10 Per-Shipment Unit Dose Factors, Units, and Multipliers for Incident-Free Rail Transportation

Receptor	Value	Units[a]	Multiply by
Public		**person-millisievert per external dose rate per**	**external dose rate × …**
Off-link rural	1.17E-07	unit population density per kilometer	rural population density × rural kilometers
Off-link suburban	1.63E-07	unit population density per kilometer	suburban population density × suburban kilometers
Off-link urban	5.62E-09	unit population density per kilometer	urban population density × rural kilometers
On-link rural	2.74E-07	kilometer	rural kilometers
On-link suburban	3.51E-06	kilometer	suburban kilometers
On-link urban	9.73E-06	kilometer	urban kilometers
Residents near rural in-transit stop	6.70E-08[b]	unit population density per kilometer	rural population density × rural kilometers
Residents near suburban in-transit stop	6.70E-08[b]	unit population density per kilometer	suburban population density × suburban kilometers
Residents near urban in-transit stop	6.70E-08[b]	unit population density per kilometer	urban population density × rural kilometers
Residents near suburban classification stop	3.14E-05	per stop	2 × trip number
Workers		**person-millisievert per external dose rate per**	**external dose rate × …**
Rail crew rural in-transit stops	3.32E-8[b]	per kilometer	rural kilometers
Rail crew suburban in-transit stops	3.32E-8[b]	per kilometer	suburban kilometers
Rail crew urban in-transit stops	3.32E-8[b]	per kilometer	urban kilometers
Worker classification stop	1.02E-02	per classification stop	2 × number of trips
Highest exposed public individual			**external dose rate ×**
Resident closest to the route	1.39E-06	rem per external dose rate per trip	total trips
Resident at stop	7.26E-06[b]	rem per external dose rate kilometer	total kilometers

Source: Sequoyah RiskModel – see Section E.5 for details.

[a] To convert kilometers to miles, multiply by 0.62137.

[b] RADTRAN 5 output for single stop divided by 555 kilometers (333 miles) per stop.

Table E-11 TIs, Population Doses, and Doses to MEIs for Alternative 3 for Truck Transportation

	Truck TI	Public Dose (person-millisievert)[b]					MEI (millisievert)[c]		Workers (person-millisievert)[b]		
Material Type	msV/hr at 1 meter[a]	On-Link[d]	Off-Link[e]	Residents Near Stops	Public at Stops	Total Public Dose	Resident Near Route	Resident Near Stop	Truck Crew in Transit	Truck Crew at Stops	Crew Total
Sludges and Sediments											
Raffinate sludge	1.12E-05	1.45E-02	5.88E-03	1.44E-04	4.49E-02	6.54E-02	3.86E-07	3.44E-04	3.78E-01	4.66E-02	4.25E-01
Emergency basin sediment	3.48E-06	2.96E-04	1.20E-04	2.93E-06	9.16E-04	1.33E-03	7.87E-09	7.02E-06	7.72E-03	9.52E-04	8.67E-03
North ditch sediment	2.17E-06	2.63E-04	1.06E-04	2.60E-06	8.12E-04	1.18E-03	6.98E-09	6.22E-06	6.84E-03	8.44E-04	7.69E-03
Sanitary lagoon sediment	6.89E-06	4.16E-04	1.69E-04	4.12E-06	1.29E-03	1.88E-03	1.11E-08	9.87E-06	1.09E-02	1.34E-03	1.22E-02
TOTALS		**1.55E-02**	**6.27E-03**	**1.53E-04**	**4.79E-02**	**6.98E-02**	**4.12E-07**	**3.67E-04**	**4.04E-01**	**4.98E-02**	**4.54E-01**

[a] To convert to mrem/hr, multiply by 100.
[b] To convert to person-rem, divide by 10.
[c] To convert to rem, divide by 10.
[d].On-link population refers to occupants of motor vehicles that share the transportation route with the shipment while moving.
[e]. Off-link population refers to members of the general public who reside or were pedestrians along the transportation route who were exposed by moving trucks.

Table E-12 TIs, Population Doses, and Doses to MEIs for Alternative 2 for Rail Transportation

	Rail TI	Public Dose (person-millisievert)[b]					MEI (millisievert)[c]		Workers (person-millisievert)[b]		
Material Type	msV/hr at 1 meter[a]	On-Link[d]	Off-Link[e]	Residents Near Stops	Public at Stops	Total Public Dose	Resident Near Route	Resident Near Stop	Rail Crew in Transit	Rail Crew at Stops	Crew Total
Sludges and sediments											
Raffinate sludge	1.44E-05	2.75E-04	2.79E-03	2.16E-03	8.79E-06	5.23E-03	1.95E-07	2.46E-03	1.13E-05	2.86E-03	2.87E-03
Pond 2 residual materials	1.33E-06	7.98E-05	8.09E-04	6.28E-04	2.55E-06	1.52E-03	5.65E-08	7.15E-04	3.27E-06	8.29E-04	8.33E-04
Emergency Basin sediment	4.63E-06	5.79E-06	5.86E-05	4.55E-05	1.85E-07	1.10E-04	4.10E-09	5.19E-05	2.37E-07	6.01E-05	6.04E-05
North Ditch sediment	2.93E-06	5.22E-06	5.29E-05	4.11E-05	1.67E-07	9.94E-05	3.70E-09	4.68E-05	2.14E-07	5.42E-05	5.45E-05
Sanitary Lagoon sediment	9.31E-06	8.27E-06	8.38E-05	6.51E-05	2.64E-07	1.57E-04	5.85E-09	7.41E-05	3.39E-07	8.59E-05	8.62E-05
Fluoride holding basin No. 1	3.54E-07	4.77E-06	4.83E-05	3.75E-05	1.52E-07	9.07E-05	3.37E-09	4.27E-05	1.95E-07	4.95E-05	4.97E-05
Fluoride holding basin No. 2	4.05E-07	5.92E-06	6.00E-05	4.66E-05	1.89E-07	1.13E-04	4.19E-09	5.31E-05	2.43E-07	6.15E-05	6.18E-05
Fluoride settling basins and clarifier	5.91E-07	5.30E-06	5.37E-05	4.17E-05	1.70E-07	1.01E-04	3.75E-09	4.75E-05	2.17E-07	5.51E-05	5.53E-05
Buried calcium fluoride	1.17E-06	8.86E-06	8.98E-05	6.97E-05	2.83E-07	1.69E-04	6.27E-09	7.94E-05	3.63E-07	9.20E-05	9.24E-05
Buried fluoride holding basin No. 1	3.51E-07	1.58E-06	1.60E-05	1.24E-05	5.04E-08	3.00E-05	1.12E-09	1.41E-05	6.47E-08	1.64E-05	1.65E-05
Liner soils and subsoils											
Clarifier liners	1.85E-07	4.84E-06	4.90E-05	3.81E-05	1.55E-07	9.20E-05	3.42E-09	4.33E-05	1.98E-07	5.02E-05	5.04E-05
Calcium fluoride basin liner	1.02E-07	7.60E-07	7.70E-06	5.98E-06	2.43E-08	1.45E-05	5.38E-10	6.81E-06	3.12E-08	7.90E-06	7.93E-06
Emergency Basin soils	7.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
North Ditch soils	5.19E-07	9.29E-06	9.41E-05	7.31E-05	2.97E-07	1.77E-04	6.58E-09	8.33E-05	3.81E-07	9.65E-05	9.69E-05
Sanitary Lagoon liner	2.13E-07	3.57E-06	3.62E-05	2.81E-05	1.14E-07	6.79E-05	2.53E-09	3.20E-05	1.46E-07	3.71E-05	3.72E-05
Buried material/drums											
Pond 1 spoils pile	3.50E-08	1.20E-07	1.22E-06	9.47E-07	3.85E-09	2.29E-06	8.51E-11	1.08E-06	4.93E-09	1.25E-06	1.25E-06
Interim storage cell	2.37E-06	1.20E-06	1.22E-05	9.47E-06	3.85E-08	2.29E-05	8.51E-10	1.08E-05	4.93E-08	1.25E-05	1.25E-05
Solid waste burials (No. 1)	1.87E-06	2.88E-05	2.92E-04	2.27E-04	9.22E-07	5.49E-04	2.04E-08	2.58E-04	1.18E-06	2.99E-04	3.01E-04
Solid waste burials (No. 2)	6.29E-07	6.30E-06	6.39E-05	4.96E-05	2.02E-07	1.20E-04	4.46E-09	5.65E-05	2.58E-07	6.55E-05	6.57E-05
DUF_4 drummed container trash	2.26E-05	4.00E-07	4.05E-06	3.15E-06	1.28E-08	7.62E-06	2.83E-10	3.59E-06	1.64E-08	4.16E-06	4.17E-06
Other drummed container trash	5.09E-07	3.91E-06	3.96E-05	3.08E-05	1.25E-07	7.44E-05	2.77E-09	3.50E-05	1.60E-07	4.06E-05	4.08E-05

Table E-12 TIs, Population Doses, and Doses to MEIs for Alternative 2 for Rail Transportation

Material Type	Rail TI	Public Dose (person-millisievert)[b]					MEI (millisievert)[c]		Workers (person-millisievert)[b]		
	msV/hr at 1 meter[a]	On-Link[d]	Off-Link[e]	Residents Near Stops	Public at Stops	Total Public Dose	Resident Near Route	Resident Near Stop	Rail Crew in Transit	Rail Crew at Stops	Crew Total
Empty Contaminated Drum	8.07E-07	2.00E-07	2.02E-06	1.57E-06	6.39E-09	3.80E-06	1.41E-10	1.79E-06	8.19E-09	2.08E-06	2.08E-06
Structural materials											
Main process building	2.27E-06	1.77E-04	1.79E-03	1.39E-03	5.65E-06	3.36E-03	1.25E-07	1.58E-03	7.25E-06	1.84E-03	1.84E-03
Solvent extraction building	2.27E-06	1.46E-05	1.48E-04	1.15E-04	4.66E-07	2.77E-04	1.03E-08	1.31E-04	5.97E-07	1.51E-04	1.52E-04
DUF_4 building	9.51E-07	9.55E-06	9.67E-05	7.51E-05	3.05E-07	1.82E-04	6.76E-09	8.55E-05	3.91E-07	9.92E-05	9.95E-05
ADU/Misc. digestion building	2.27E-06	1.01E-06	1.03E-05	7.97E-06	3.24E-08	1.93E-05	7.16E-10	9.07E-06	4.15E-08	1.05E-05	1.06E-05
Laundry building	2.27E-06	1.21E-06	1.23E-05	9.56E-06	3.88E-08	2.31E-05	8.60E-10	1.09E-05	4.98E-08	1.26E-05	1.27E-05
Centrifuge building	2.27E-06	2.43E-06	2.46E-05	1.91E-05	7.77E-08	4.62E-05	1.72E-09	2.18E-05	9.96E-08	2.52E-05	2.53E-05
Bechtel building	2.27E-06	2.19E-06	2.22E-05	1.72E-05	6.99E-08	4.16E-05	1.55E-09	1.96E-05	8.96E-08	2.27E-05	2.28E-05
Solid waste building	2.27E-06	1.46E-06	1.48E-05	1.15E-05	4.66E-08	2.77E-05	1.03E-09	1.31E-05	5.97E-08	1.51E-05	1.52E-05
Cooling tower	2.27E-06	2.43E-06	2.46E-05	1.91E-05	7.77E-08	4.62E-05	1.72E-09	2.18E-05	9.96E-08	2.52E-05	2.53E-05
RCC evaporator	2.27E-06	1.52E-06	1.54E-05	1.19E-05	4.86E-08	2.89E-05	1.07E-09	1.36E-05	6.22E-08	1.58E-05	1.58E-05
Incinerator	2.27E-06	6.07E-07	6.15E-06	4.78E-06	1.94E-08	1.16E-05	4.30E-10	5.44E-06	2.49E-08	6.31E-06	6.33E-06
Concrete and asphalt	2.27E-06	2.07E-04	2.10E-03	1.63E-03	6.63E-06	3.94E-03	1.47E-07	1.86E-03	8.49E-06	2.15E-03	2.16E-03
Contaminated material	1.46E-07	1.31E-06	1.32E-05	1.03E-05	4.18E-08	2.49E-05	9.26E-10	1.17E-05	5.36E-08	1.36E-05	1.36E-05
Chipped Pallets	0.00E+00	1.77E-04	1.79E-03	1.39E-03	5.65E-06	3.36E-03	1.25E-07	1.58E-03	7.25E-06	1.84E-03	1.84E-03

Table E-12 TIs, Population Doses, and Doses to MEIs for Alternative 2 for Rail Transportation

	Rail TI	Public Dose (person-millisievert)[b]					MEI (millisievert)[c]		Workers (person-millisievert)[b]		
Material Type	**msV/hr at 1 meter[a]**	**On-Link[d]**	**Off-Link[e]**	**Residents Near Stops**	**Public at Stops**	**Total Public Dose**	**Resident Near Route**	**Resident Near Stop**	**Rail Crew in Transit**	**Rail Crew at Stops**	**Crew Total**
Subsoils and bedrock											
Contaminated materials	7.48E-07	2.10E-04	2.13E-03	1.65E-03	6.72E-06	4.00E-03	1.49E-07	1.88E-03	8.61E-06	2.18E-03	2.19E-03
TOTALS		**1.09E-03**	**1.11E-02**	**8.60E-03**	**3.50E-05**	**2.08E-02**	**7.74E-07**	**9.80E-03**	**4.48E-05**	**1.14E-02**	**1.14E-02**

[a] To convert to mrem/hr, multiply by 100.
[b] To convert to person-rem, divide by 10.
[c] To convert to rem, divide by 10.
[d] On-link population refers to occupants of trains that share the transportation route with the shipment while moving.
[e] Off-link population refers to members of the general public who reside or were pedestrians along the transportation route who were exposed by moving rail cars.

unit dose factors, then multiplied the unit dose factors by the package-specific external dose rate and other factors (see Tables E-9 and E-10 for details).

RADTRAN 5 was used to calculate unit dose factors using the appropriate input parameters. Basic features of the RADTRAN 5 model are (1) the shipping package and truck bed combination are spherically symmetric and (2), while the actual radiation source is the shipping package external dose rate, the model uses an isotropic emission at the center of the sphere as the source (i.e., a point source) (Neuhauser, 2000). The dose to a distant receptor is directly proportional to the dose rate buildup, which is the product of a buildup factor and an attenuation factor. For gamma radiation, this product is equal to unity in RADTRAN 5 because it is always less than or equal to 1 (Neuhauser, 2000).

The dose is inversely proportional to the square of the distance between the receptor and the center of the cargo (the truck bed). When the receptor is within about a package length, as could be the case for crew members and inspectors, the model bases external dose rate on a line source, and the dose to the receptor is inversely proportional to the distance between the receptor and the center of the cargo.

Dose is directly proportional to exposure time. The dose to a stationary receptor from a moving vehicle carrying radioactive cargo, i.e., the off-link dose, is inversely proportional to the speed of the vehicle.

This analysis assigned values of 1 to some variables in the RADTRAN 5 input for the calculation of unit dose factors for rural, suburban, and urban segments of the various routes for each mode (truck and rail). The products of the resulting table of unit dose factors, multiplied by the applicable shipment kilometers, exposed populations, etc., are then the off-link, incident-free doses for each segment of each route. This analysis then combines these doses to determine total collective dose.

To calculate potential in-transit doses to truck crews, the analysis assumed that the crew would remain at a fixed distance (1.5 meters [4.9 feet]) from the package for the duration of the route. RADTRAN 5 bases the end-on radiation dose rate on the given TI.

Doses to occupants of other vehicles sharing the transportation corridor, i.e., the on-link doses, require a more complex set of assumptions about vehicle speed (Neuhauser, 2000). RADTRAN 5 bases the calculation of on-link doses on Equations 31 to 34 of Neuhauser, 2000. In RADTRAN 5, the relative speed of vehicles that move in the same direction as the contaminated material shipment is twice the contaminated material vehicle speed when the vehicle is passing the contaminated material vehicle (contaminated material vehicle is stationary), and zero if the vehicle is traveling in a lane next to the contaminated material vehicle. In addition, the density of vehicles that move in the opposite direction is inversely proportional to the vehicle speed. Overall, the on-link dose is inversely proportional to the square of the vehicle speed (Neuhauser, 2000).

RADTRAN 5 calculated national per-kilometer, on-link unit dose factors for each mode and shipment for each population zone using national average vehicle densities. The Sequoyah RiskModel then multiplied each unit dose factor by route segment length, number of shipments, and package length. Vehicles that shared the route with the radioactive cargo would provide no radiation shielding for their occupants.

E.3.1.3 Analysis of Doses at Stops

Figure E-2 shows the rest and refueling stop model for the analysis for truck shipments. RADTRAN 5 allows each stop, or type of stop, along a route to be modeled individually. The modeled stops and affected populations in this analysis are:

- Truck stops for rest and refueling and the nearby truck crews and residents.
- Classification stops at the origin and destination of a rail trip and the nearby rail crews, inspectors, and residents.
- In-transit classification stops for a rail trip and the nearby rail crews, inspectors, and residents.

DOE (2002a) provided the exposure data for members of the public at rest and refueling stops. RADTRAN 5 calculates a population dose per stop. Calculation of a unit dose factor, in units of person-rem per kilometer, requires an estimate of the number of stops per kilometer of travel, which in turn requires an estimate of how many kilometers the trucks travel between rest and refueling stops.

The model uses the appropriate rural, suburban, or urban population density (depending on whether the stop is in a rural, suburban, or urban area) and the same distance from the shipment as for the off-link dose calculation (30 to 800 meters [about 100 feet to 0.5 mile]) to estimate potential doses to residents who live near the truck stops.

In addition to the model for a rest and refueling stop, for which RADTRAN 5 calculates the dose to a population that is evenly distributed in an area around the source, the RADTRAN 5 stop model allows calculation of dose to receptors at a fixed distance from the source (e.g., dose to an individual at an assumed distance from the vehicle).

The Sequoyah RiskModel uses unit dose factors per kilometer of route length and Equations 37 and 38 or 39 to 41 of Neuhauser, 2000) to calculate stop dose. The model then divides the result by the average distance between stops to derive a per-kilometer unit dose factor. To convert the unit dose factor to a per-kilometer number, the model divides it either by 1,206 kilometers (725 miles) for trucks, which is the average distance between truck stops, or by 555 kilometers (333 miles) for rail. The Sequoyah RiskModel then multiplies the per-kilometer factor by the distance from each origin to destination and by the number of shipments from each origin site.

Appendix B of Neuhauser, 2000 describes the classification stop model of RADTRAN 5. This analysis evaluated two types of classification stops:

- **Terminal classification stop.** The analysis assumed two terminal classification stops per trip (one at the beginning and one at the end of each trip) that last for 30 hours each.

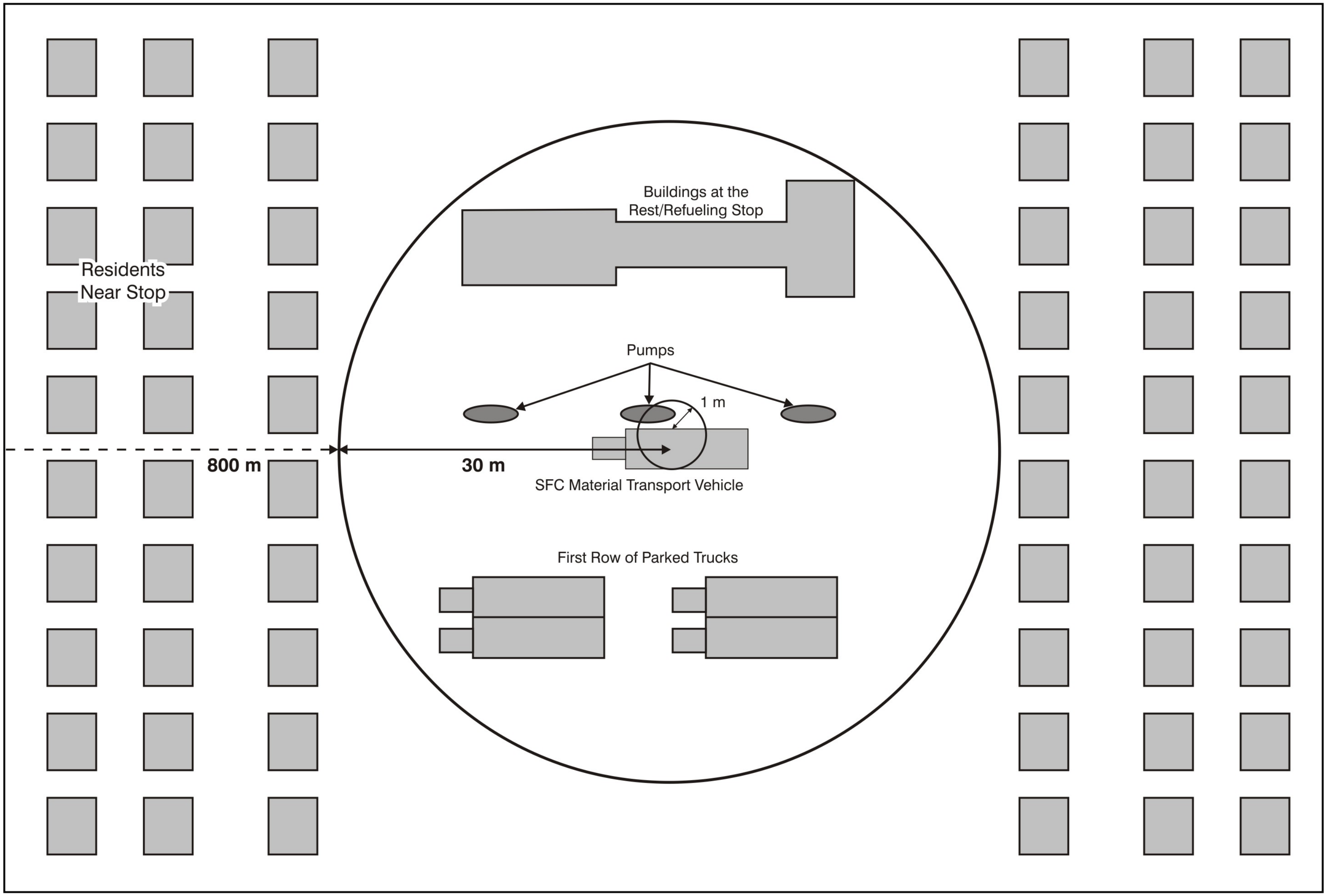

Figure E-2 Rest and Refueling Stop Model

- **In-transit classification stop.** This category represents classification stops that could occur along the route (adding and dropping railcars). The analysis conservatively assumed that in-transit classification stops would total 33 hours for each 555 kilometers traveled.

RADTRAN 5 incorporates the occupational dose at a classification stop, and the user inputs the number of classification stops per trip. This analysis assumed there would be one classification stop at the origin site (or at the closest railhead if the origin site has no rail access) and a second classification stop at the destination. The calculation of doses to residents near the rail stops used the same methods as those for doses to residents near truck stops.

E.3.2 Incident-Free Doses to Individuals

This section describes the scenarios for and calculation of potential incident-free radiological impacts on individuals during the transportation of contaminated material to disposal facilities.

The analysis used RADTRAN 5 to estimate exposures to individuals and based them on transportation of the total number of shipments by both truck and by rail. For public exposures, the analysis assumed an individual could be exposed to all shipments along a route. In addition, the estimates of maximum annual exposures to individuals used the conservative assumption that all shipments would occur during one year.

The MEI is a hypothetical person who would receive the highest dose. Because different individuals could receive the highest doses under different exposure scenarios, the analysis evaluated the following exposure scenarios:

- **Truck driver.** A truck driver is the MEI for all alternatives and exposure scenarios. This individual would be 1.5 meters (4.9 feet) from the shipping package during transport. Exposure from transport of the contaminated material depends upon the travel time to the off-site disposal site (e.g., Clive, Utah). The Sequoyah RiskModel performs this calculation.

- **Resident near route.** The analysis assumed a resident who lives 30 meters (100 feet) from a point where shipments would pass (truck and rail). The resident would be exposed to all truck and rail shipments along a particular route.

- **Resident near rail terminal classification and in-transit rail stops.** The analysis assumed a resident who lives within 30 meters (100 feet) of a switchyard and an exposure time of 30 hours for classification stops and 10 hours for in-transit stops.

- **Resident near truck stop.** The analysis assumed a member of the public would be exposed to shipments for 1.69 hours for each occurrence at a distance of 30 meters (100 feet).

RADTRAN 5 estimates values for exposure to one shipment for each of the individual exposure scenarios. The dose to the MEIs is then the product of these estimated exposures and the number of shipments that might pass or stop at the assumed locations. Table E-13 lists potential MEI doses for rail and truck shipments for the entire shipping campaign.

Table E-13 Radiation Doses to MEIs by Alternative[a]

Doses	Alternative 2 All Off-site Disposal (millisievert)[b]	Alternative 3 Partial Off-site Disposal (millisievert)[b]
Rail		
Resident near rail route	7.74E-07	NA[c]
Resident near a rail stop	9.80E-03	NA[c]
Truck		
Truck driver – **MEI**[e]	NA[c]	1.26E-02
Resident near truck route	NA[c]	4.12E-07
Resident near truck stop	NA[c]	3.67E-04

[a] Calculated by RADTRAN 5 and Sequoyah RiskModel.
[b] To convert to rem, divide by 10.
[c] Not Applicable
[d] Assumes a total of 18 truck crews with 2 crew members per truck.

E.3.3 Vehicle Emission Unit Risk Factors

This section describes the development of unit risk factors for estimating potential fatalities from exhaust and fugitive dust emissions from highway and rail transportation. These risk factors, which were obtained from the Yucca Mountain Repository environmental impact statement (EIS) (DOE, 2002b), were deemed appropriate for use in this analysis because they account for heavy truck traffic and freight rail traffic for any cargo. To bound potential impacts, this analysis used the conservative assumption that emissions from personal (i.e., commuter) vehicles would be equal to those from trucks. This assumption ensured the analysis did not underestimate potential impacts.

Table E-14 lists the unit risk factors in units of fatalities per kilometer per person per square kilometer. The analysis multiplied these factors by the appropriate population-weighted distances (see Tables E-3 and E-15) and the number of shipments (see Table E-1) to calculate the number of potential vehicle emissions fatalities. Table E-16 lists the vehicle emissions fatalities and the vehicle traffic accident injuries and fatalities by alternative.

Table E-14 Vehicle Emission Unit Risk Factors

Vehicle Class	Weight (tons)	Tire/Brake Particulates (g/km)	Fugitive Dust (g/km)	Diesel Exhaust (g/km)	Total Emissions (g/km)	Unit Risk Factor (fatalities/km per person/km^2)
Class VIIIB Trucks	40	0.030	0.26	0.141	0.43	1.5E-11
Railcar	N/A	N/A	0.26	0.481	0.74	2.6E-11

Source: DOE, 2002a.

Table E-15 Daily Local and Off-Site Traffic, Number of Trips, and Total Mileage by Alternative – Number of Estimated Trips and Mileage[a]

Type of Vehicle Traffic	Estimated One-Way (kilometers)[a]	No-Action Alternative	Alternative 1 On-site Disposal	Alternative 2 Off-site Disposal	Alternative 3 Partial Off-site Disposal[a]
Daily local traffic					
Commuting workers	40.2	6	75	75	75
Normal deliveries	40.2	6	75	75	75
Fly ash	82.1	0	28	0	27
Riprap from off-site	12.9	0	40	0	38
Riprap from on-site	1.6	0	40	0	38
Sand, drain layer, and bedding	12.9	0	9	0	8
Clay liner and clay cap	1.6	0	40	0	38
Clean backfill	1.6	0	85	85	85
Topsoil	1.6	0	13	13	13
Total daily two-way vehicle count		24	784	470	768
Total daily two-way kilometers[b]		966	18,502	12,386	18,247
Total local kilometers[b]		241,410	4,625,416	3,096,486	4,561,844
Off-site traffic					
Daily two-way off-site radioactive material truck shipments		0	0	0	5
Daily two-way off-site radioactive material railcar shipments		0	0	21	0
Total two-way off-site radioactive material truck kilometers[b]		0	0	0	2,794,550
Total two-way off-site radioactive material rail kilometers[b]		0	0	17,829,238	0

Source: SFC, 2005.
[a] To convert to miles, divide by 1.6094.
[b] Assumes 250 working days per year.

Table E-16 Local and Off-site Nonradiological Impacts (Injuries and Fatalities) by Alternative

Mode	Alternative 1 On-site Disposal		Alternative 2 All Off-site Disposal		Alternative 3 Partial Off-site Disposal		No-Action Alternative	
	Vehicle Emissions Fatalities	Traffic Accident Injuries/ Fatalities	Vehicle Emissions Fatalities	Traffic Accident Injuries/ Fatalities	Vehicle Emissions Fatalities	Traffic Accident Injuries/ Fatalities	Vehicle Emissions Fatalities	Traffic Accident Injuries/ Fatalities
Nonradiological impacts of off-site transportation								
Trucks	NA	NA	NA	NA	1.75E-03[a]	6.68E-01/ 3.97E-02	NA	NA
Railcar	NA	NA	4.41E-02	2.09/ 1.39E+00	NA	NA	NA	NA
Nonradiological impacts of local transportation								
	Vehicle Emissions Fatalities[b]	**Traffic Accident Injuries/ Fatalities[c]**	**Vehicle Emissions Fatalities[b]**	**Traffic Accident Injuries/ Fatalities[c]**	**Vehicle Emissions Fatalities[b]**	**Traffic Accident Injuries/ Fatalities[c]**	**Vehicle Emissions Fatalities[b]**	**Traffic Accident Injuries/ Fatalities[c]**
Trucks	5.48E-04	1.32/ 6.80E-02	3.67E-04	8.82E-01/ 4.55E-02	5.41E-04	1.30/ 6.71E-02	2.86E-05	6.88e-02/ 3.55E-03

[a] Assumes population densities along the route; see Table E-3.
[b] Assumes rural population density of 7.9 people per square kilometer; see Table E-3.
[c] Assumes Oklahoma truck accident rate of 1.47E-08 fatalities per kilometer (DOE, 2002a).
NA = Not Applicable

E.4 Transportation Accidents

E.4.1 Nonradiological Transportation Accidents

This section describes the analysis of nonradiological transportation accident impacts (e.g., traffic fatalities) that could result from accidents that involve contaminated materials. The analysis used truck and railcar injury rates per kilometer of 2.39×10^{-7} and 6.56×10^{-8}, respectively (DOE, 2002a, Tables 6.38 and 6.40), to estimate the total number of injuries that could occur for the truck and rail cases for all alternatives. The analysis used truck and railcar fatality rates per kilometer of 1.42×10^{-8} and 7.82×10^{-8}, respectively (DOE, 2002a, Tables 6.39 and 6.40), to estimate the total number of fatalities that could occur for the truck and rail cases for all alternatives. The analysis multiplied the distance to be traveled by the national composite fatal accident rates to obtain an estimate of the total number of potential fatalities for each case.

The Sequoyah RiskModel calculated potential traffic fatalities from contaminated material transportation by multiplying the appropriate accident rates by the kilometers per shipment and the number of shipments. Table E-17 lists the calculated estimates of fatalities for each alternative.

Table E-17 Potential Truck or Rail Traffic Accident Injuries and Fatalities by Alternative

Mode	Alternative 1 On-site Disposal (Injuries/ Fatalities)	Alternative 2 Off-site Disposal (Injuries/ Fatalities)	Alternative 3 Partial Off-site Disposal (Injuries/ Fatalities)	No-Action Alternative (Injuries/ Fatalities)
Truck	1.32/ 6.80E-02	8.82E-01/ 4.55E-02	6.68E-01/ 1.07E-01	6.88E-02/ 3.55E-03
Rail	NA	2.09/ 1.39	NA	NA

NA = not applicable.

E.4.2 Radiological Transportation Accidents

This section describes the analysis of collective population and individual doses from potential accidents during contaminated material transpiration. The radiation doses that could result from a transportation accident involving radioactive material depend on the amount of radioactive material the accident releases into the environment. The amount of released material depends in turn on (1) the ability of the shipping package to withstand the mechanical and thermal stresses of an accident and (2) the physical behavior of the contaminated material in an accident.

Section E.4.2.1 describes the characteristics of the disposal package that the analysis assumed for the accident. Section E.4.2.2 discusses the analysis methods. Section E.4.2.3 discusses the assumptions and presents the results.

E.4.2.1 Radionuclide Content and Source Term

To define the maximum reasonably foreseeable accident, the analysis screened the radionuclide-specific unit dose factors (from RADTRAN 5 unit accident runs in the Sequoyah RiskModel) to determine the shipping package that could contain the radionuclide mix with the highest potential radiotoxicity, which would represent the highest potential for radiation dose under any accident scenario. The Sequoyah RiskModel screening analysis determined that shipments of raffinate sludge would have the radionuclide mix and quantities with the highest potential radiotoxicity. Table E-18 lists the potential quantities of radionuclides. Although railcars carry more material per car than trucks, the analysis assumed the maximum reasonably foreseeable accident would involve a truck because the truck accident rate is higher and the atmospheric dispersion of radioactive materials would be greater due to the larger amount of kinetic energy likely to be imparted to the contaminated material.

Table E-18 Shipping Package Radionuclide Content for the Maximum Reasonably Foreseeable Truck Accident

Radionuclide	Activity per Truck Load[a] (curies)[b]
U-234	2.96E-02
U-235	1.39E-03
U-238	2.91E-02
Ra-226	1.91E-03
Th-230	4.52E-01
Total Activity	5.14E-01

[a] Assumes 18 supersacks per load and 998 kilograms (2,200 pounds per supersack.
[b] To convert to becquerels, multiply by 3.7E10.

The assumptions of the maximum reasonably foreseeable accident include a release fraction of 1 (i.e., all material in the package), an aerosol fraction of 0.1 (DOE 2002a, pg. 105, small powder), and a respirable fraction (particles small enough to inhale into the lungs) of the radionuclides of 0.05 (DOE 2002a, loose chunks).

E.4.2.2 Method

The analysis calculated the radionuclide-specific unit dose factors in terms of dose per released curie. The analysis assumed the maximum reasonably foreseeable accident would result in the release of all of the radioactive material, of which 10% would be in aerosol form, dispersed into the air with 5% of respirable particle size. The analysis used RADTRAN 5 to calculate the dose per curie of each radionuclide, i.e., the radionuclide-specific unit dose factor.

The analysis calculated inhalation, resuspension, groundshine, and cloudshine unit dose factors for 1 curie of each radionuclide by applying the curie-to-rem, radionuclide-specific dose conversion factors in the RADTRAN 5 internal library. RADTRAN 5 calculated the total accident dose for each pathway and the fraction of that dose attributable to each radionuclide. Section E.4.2.3 discusses other parameters that are part of the unit dose factors.

The analysis modeled the exposed population for a release of radioactive material by assuming that the population density in the 800-meter (0.5-mile) -wide corridor on either side of the route was the same population density under the entire plume, out to 120 kilometers (75 miles) from the accident. RADTRAN 5 calculates both short- and long-term (50-year) doses; the unit dose factor is the sum of the short-term and long-term unit dose factors.

E.4.2.3 Assumptions

To determine the dose factors in terms of dose per curie of a released radionuclide, the analysis calculated atmospheric dispersion to obtain the downwind airborne and ground concentrations from cloud depletion. The analysis made the following major assumptions for the development of dose factors for the radionuclide-specific unit dose factors for the assumed contaminated material shipment:

- Meteorological conditions would be U.S. national average (50th-percentile meteorology).
- Deposition velocity (for groundshine and ingestion doses) would be 0.01 meter per second (0.023 mile per hour) for volatiles and particulates.
- All receptors would breath outside air that contained radionuclides from the accident.
- Evacuation would occur within 24 hours.
- Interdiction (i.e., cleanup) after an accident would prevent additional exposures after evacuation.
- Released and dispersed radioactive material would have a 100% release fraction, a 10% aerosol fraction, and a 5% respirable fraction.

The analysis used RADTRAN 5 default values for other parameters such as breathing rate.

This section describes the development of unit collective dose factors (person-rem per curie released) for each radionuclide. Tables E-19 and E-20 list the unit dose factors for each radionuclide for rural/suburban and urban accidents, respectively. The analysis developed separate factors to account for the shielding of buildings in suburban and urban areas. Table E-21 lists the total unit dose factors for individual doses, which includes doses from inhalation, cloudshine, and groundshine during evacuation.

The analysis estimated the collective and individual doses from a given accident by multiplying each unit dose factor from Table E-19, E-20, or E-21 (depending on assumed location and receptor) by the released quantity of that radionuclide (package content multiplied by its release fraction). The sum of these products is the total collective dose in person-rem or the individual dose in rem.

Table E-19 Population Unit Dose Factors for Rural and Suburban Accidents by Radionuclide and Exposure Pathway

Radionuclide	Rural and Suburban Accident Dose Factors (person-millisievert[a] per curie released)				
	Inhalation	Resuspended	Groundshine	Cloudshine	Total
U-234	1.73E-02	1.44E-04	7.16E-04	2.20E-09	1.82E-02
U-235	1.53E-02	1.28E-04	1.42E-01	2.10E-06	1.57E-01
U-238	1.42E-02	1.19E-04	5.20E-04	1.02E-09	1.49E-02
Ra-226	1.73E-02	1.44E-04	6.11E-03	9.44E-08	2.36E-02
Th-230	2.12E-01	1.77E-03	7.19E-04	5.20E-09	2.14E-01

Source: RADTRAN 5 calculation.
[a] To convert to person-rem, divide by 10.

Inhalation Dose: Dose resulting from inhalation of radioactive particles in the plume.
Resuspended Dose: Dose resulting from inhalation of radioactive particles resuspended from the ground.
Groundshine Dose: Dose resulting from exposure to radioactive particles deposited on the ground.
Cloudshine Dose: Dose resulting from exposure to radioactive particles suspended in the plume.

Table E-20 Population Unit Dose Factors for Urban Accidents by Radionuclide and Exposure Pathway

Radionuclide	Urban Accident Dose Factors (person-milisievert[a] per curie released)				
	Inhalation	Resuspended	Groundshine	Cloudshine	Total
U-234	5.03E-02	4.20E-04	2.08E-03	6.61E-09	5.28E-02
U-235	4.45E-02	3.71E-04	4.12E-01	6.24E-06	4.57E-01
U-238	4.14E-02	3.46E-04	1.53E-03	2.95E-09	4.33E-02
Ra-226	5.03E-02	4.20E-01	1.78E-02	2.74E-07	6.85E-02
Th-230	6.15E-01	5.14E-03	2.09E-03	1.51E-08	6.22E-01

Source: RADTRAN 5 calculation.
[a] To convert to person-rem, divide by 10.

Table E-21 Individual Unit Dose Factors by Radionuclide (millisievert[a] per curie released)

Radionuclide	Total
U-234	5.450
U-235	4.820
U-238	4.610
Ra-226	5.660
Th-230	0.796

Source: RADTRAN 5 calculation.
[a] To convert to rem, divide by 10.

The analysis calculated the collective and individual doses under the conservative assumption that the accident would release all radioactive material in the shipment (see Table E-20). Table E-22 summarizes the collective doses for rural and urban locations and the individual doses from the maximum accident.

Table E-22 Collective and Individual Doses Resulting from the Maximum Reasonably Foreseeable Accident

Radionuclide	Activity Released (curies)[a]	Rural Population Dose (person-millisievert)[b]	Urban Population Dose (person-millisievert)[b]	Individual Dose (millisievert)[c]
U-234	1.48E-04	2.13E-05	8.49E-04	8.07E-04
U-235	6.97E-05	8.64E-06	3.45E-04	3.36E-05
U-238	1.45E-04	1.71E-05	6.83E-04	6.70E-04
Ra-226	9.54E-06	1.78E-06	7.10E-05	5.40E-05
Th-230	2.26E-03	3.82E-03	1.52E-01	1.80E-03
Total	2.57E-03	3.87E-03	1.54E-01	3.36E-03

Source: Sequoyah RiskModel.
[a] To convert to becquerels, multiply by 3.7E10.
[b] To convert to person-rem, divide by 10.
[c] To convert to person-rem, divide by 10.

E.5 Summary of Transportation Impacts

This section discusses the conversion of collective and individual radiation doses to the potential for (or risk of) adverse health effects. Section E.5.1 provides the method for conversion of dose to LCFs, and Section E.5.2 summarizes potential radiological and nonradiological transportation impacts.

E.5.1 Radiation Dose and Latent Cancer Fatalities

The NRC staff estimated the probability of LCFs for members of the public by using a dose-to-risk conversion factor of 6×10^{-9} per millisievert (6×10^{-7} per millirem) for members of the public. The U.S. Environmental Protection Agency (EPA) recommends this factor for the general population (Eckerman et al., 1999). This factor considers all age groups in the population, including infants and children, who are more sensitive to radiation than adults. Because workers would be 18 or more years old, the analysis used a separate, smaller dose-to-risk conversion factor for workers of 4×10^{-9} per millisievert (4×10^{-7} per millirem) (ICRP, 1990, p. 22).

The analysis used these factors to estimate the effects of exposing a population to radiation. For example, if each of 100,000 people was exposed only to background radiation (3 millisievert, or 0.03 millirem per year), an estimated 18 LCFs would occur as a result of one year of exposure (100,000 persons multiplied by 3 millisievert per year multiplied by 6×10^{-9} LCF per person-millisievert).

This EIS expresses radiological health impacts as incremental changes in the number of expected LCFs for the off-site public and for transportation workers. Because of the uncertainties in dose response to low dose rates, the impact estimates provide a general indication of possible health impacts (the potential number of induced cancers), but readers should not interpret these estimates as exact numbers of induced cancers or as an indication of who could contract a cancer.

E.5.2 Transportation-Related Human Health Impacts

The analysis multiplied the population and individual doses (see Tables E-11 to E-13 and E-22) by the dose-to-health-effect conversion factors (see Section E.5.1) to estimate (1) the number of fatal cancers in the affected populations and (2) the individual incremental probability of contracting a fatal cancer. Tables E-23 and E-24 list the estimated radiological impacts for the various alternatives from transportation activities for the entire contaminated material shipping campaign, which the analysis assumed would last one year. Table E-25 lists the increased risks of LCFs for the MEIs (public and workers) by alternative. Table E-26 summarizes collective and individual impacts from the maximum foreseeable accident.

E.5.3 Impact Comparison by Off-site Contaminated material Destination

As discussed in Section E.2.2, the previous sections have presented transportation-related human health impacts assuming that all off-site shipments were to be sent to the Energy Solutions facility in Clive, Utah. This was done because of the likelihood that the contaminated material would actually be sent to Clive and because the distance traveled would be greater than to either of the facilities in Blanding, Utah, or Andrews, Texas. Impacts such as vehicle emission and traffic fatalities, which are dependant only on the total number of miles traversed, would be reduced by about 27% and 53% for truck transport for Blanding, Utah, and Andrews, Texas, respectively; these impacts would be reduced by about 13% and 50% for rail transport for Blanding, Utah, and Andrews, Texas, respectively. The potential impacts from radiological accidents would not be different for any of the proposed destinations.

Other impacts provided in Section E.5 are dependant on both the total number of miles traveled and the populations living along the transportation corridors. Although the distance from the SFC facility to Clive, Utah, is greater than that to either Blanding, Utah, or Andrews, Texas, the populations potentially affected along the truck transportation corridor is greater for Blanding than for Clive or Andrews. Therefore, collective population impacts are greater for truck transportation to Blanding than for Clive or Andrews, while impacts on the MEI remain the same or are less. Tables E-27 through E-29 provide comparisons for all of the radiological impacts for each destination.

Table E-23 Radiological Impacts for Alternative 3 by Material Type for Truck Transport

Material Type	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
	On-Link	Off-Link	Residents Near Stops	Public at Stops	Total Public	Resident Near Route	Resident Near Stop	Truck Crew in Transit	Truck Crew at Stops	Crew Total
Sludges and Sediments										
Raffinate sludge	8.71E-07	3.53E-07	8.62E-09	2.69E-06	3.92E-06	2.32E-11	2.06E-08	1.51E-05	1.87E-06	1.70E-05
Emergency Basin sediment	1.78E-08	7.20E-09	1.76E-10	5.49E-08	8.01E-08	4.72E-13	4.21E-10	3.09E-07	3.81E-08	3.47E-07
North Ditch sediment	1.58E-08	6.38E-09	1.56E-10	4.87E-08	7.10E-08	4.19E-13	3.73E-10	2.74E-07	3.37E-08	3.08E-07
Sanitary Lagoon sediment	2.50E-08	1.01E-08	2.47E-10	7.72E-08	1.13E-07	6.64E-13	5.92E-10	4.34E-07	5.35E-08	4.88E-07
TOTAL	**9.29E-07**	**3.76E-07**	**9.20E-09**	**2.87E-06**	**4.19E-06**	**2.47E-11**	**2.20E-08**	**1.62E-05**	**1.99E-06**	**1.81E-05**

Table E-24 Radiological Impacts for Alternative 2 by Material Type for Rail Transport

Material Type	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
	On-Link	Off-Link	Residents Near Stops	Public at Stops	Total Public	Resident Near Route	Resident Near Stop	Rail Crew in Transit	Rail Crew at Stops	Crew Total
Sludges and sediments										
Raffinate sludge	1.65E-08	1.67E-07	1.30E-07	5.27E-10	3.14E-07	1.17E-11	1.48E-07	4.51E-10	1.14E-07	1.15E-07
Pond 2 residual materials	4.79E-09	4.85E-08	3.77E-08	1.53E-10	9.12E-08	3.39E-12	4.29E-08	1.31E-10	3.32E-08	3.33E-08
Emergency Basin sediment	3.47E-10	3.52E-09	2.73E-09	1.11E-11	6.61E-09	2.46E-13	3.11E-09	9.49E-12	2.40E-09	2.41E-09
North Ditch sediment	3.13E-10	3.17E-09	2.47E-09	1.00E-11	5.96E-09	2.22E-13	2.81E-09	8.56E-12	2.17E-09	2.18E-09
Sanitary Lagoon sediment	4.96E-10	5.03E-09	3.90E-09	1.59E-11	9.44E-09	3.51E-13	4.44E-09	1.36E-11	3.44E-09	3.45E-09
Fluoride holding basin No. 1	2.86E-10	2.90E-09	2.25E-09	9.14E-12	5.44E-09	2.02E-13	2.56E-09	7.81E-12	1.98E-09	1.99E-09
Fluoride holding basin No. 2	3.55E-10	3.60E-09	2.80E-09	1.14E-11	6.76E-09	2.52E-13	3.18E-09	9.71E-12	2.46E-09	2.47E-09
Fluoride settling basins and clarifier	3.18E-10	3.22E-09	2.50E-09	1.02E-11	6.05E-09	2.25E-13	2.85E-09	8.69E-12	2.20E-09	2.21E-09
Buried calcium fluoride	5.32E-10	5.39E-09	4.18E-09	1.70E-11	1.01E-08	3.76E-13	4.76E-09	1.45E-11	3.68E-09	3.70E-09
Buried fluoride holding basin No. 1	9.47E-11	9.59E-10	7.45E-10	3.03E-12	1.80E-09	6.70E-14	8.48E-10	2.59E-12	6.55E-10	6.58E-10
Liner soils and subsoils										
Clarifier liners	2.90E-10	2.94E-09	2.28E-09	9.28E-12	5.52E-09	2.05E-13	2.60E-09	7.93E-12	2.01E-09	2.02E-09
Calcium fluoride basin liner	4.56E-11	4.62E-10	3.59E-10	1.46E-12	8.68E-10	3.23E-14	4.09E-10	1.25E-12	3.16E-10	3.17E-10
Emergency Basin soils	5.58E-10	5.65E-09	4.39E-09	1.78E-11	1.06E-08	3.95E-13	5.00E-09	1.52E-11	3.86E-09	3.88E-09
North Ditch soils	2.14E-10	2.17E-09	1.69E-09	6.85E-12	4.08E-09	1.52E-13	1.92E-09	5.85E-12	1.48E-09	1.49E-09
Sanitary Lagoon liner	5.67E-11	5.74E-10	4.46E-10	1.81E-12	1.08E-09	4.01E-14	5.08E-10	1.55E-12	3.92E-10	3.94E-10
Buried material/drums										
Pond 1 spoils pile	7.22E-11	7.31E-10	5.68E-10	2.31E-12	1.37E-09	5.11E-14	6.47E-10	1.97E-12	5.00E-10	5.02E-10
Interim storage cell	1.73E-09	1.75E-08	1.36E-08	5.53E-11	3.29E-08	1.22E-12	1.55E-08	4.73E-11	1.20E-08	1.20E-08

Table E-24 Radiological Impacts for Alternative 2 by Material Type for Rail Transport

	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
Material Type	On-Link	Off-Link	Residents Near Stops	Public at Stops	Total Public	Resident Near Route	Resident Near Stop	Rail Crew in Transit	Rail Crew at Stops	Crew Total
Solid waste burials (No. 1)	3.78E-10	3.83E-09	2.98E-09	1.21E-11	7.20E-09	2.68E-13	3.39E-09	1.03E-11	2.62E-09	2.63E-09
Solid waste burials (No. 2)	2.40E-11	2.43E-10	1.89E-10	7.68E-13	4.57E-10	1.70E-14	2.15E-10	6.56E-13	1.66E-10	1.67E-10
DUF_4 drummed container trash	2.35E-10	2.38E-09	1.85E-09	7.50E-12	4.46E-09	1.66E-13	2.10E-09	6.41E-12	1.62E-09	1.63E-09
Other drummed container trash	1.20E-11	1.21E-10	9.43E-11	3.83E-13	2.28E-10	8.48E-15	1.07E-10	3.28E-13	8.30E-11	8.33E-11
Empty contaminated drum	7.61E-12	7.70E-11	5.98E-11	2.43E-13	1.45E-10	5.38E-15	6.81E-11	2.08E-13	5.27E-11	5.29E-11
Structural Materials										
Main process building	1.06E-08	1.07E-07	8.35E-08	3.39E-10	2.02E-07	7.51E-12	9.50E-08	2.90E-10	7.35E-08	7.37E-08
Solvent extraction building	8.75E-10	8.86E-09	6.88E-09	2.80E-11	1.66E-08	6.19E-13	7.84E-09	2.39E-11	6.06E-09	6.08E-09
DUF_4 building	5.73E-10	5.80E-09	4.51E-09	1.83E-11	1.09E-08	4.05E-13	5.13E-09	1.57E-11	3.97E-09	3.98E-09
ADU/Misc. digestion building	6.07E-11	6.15E-10	4.78E-10	1.94E-12	1.16E-09	4.30E-14	5.44E-10	1.66E-12	4.21E-10	4.22E-10
Laundry building	7.29E-11	7.38E-10	5.73E-10	2.33E-12	1.39E-09	5.16E-14	6.53E-10	1.99E-12	5.05E-10	5.07E-10
Centrifuge building	1.46E-10	1.48E-09	1.15E-09	4.66E-12	2.77E-09	1.03E-13	1.31E-09	3.98E-12	1.01E-09	1.01E-09
Bechtel building	1.31E-10	1.33E-09	1.03E-09	4.19E-12	2.50E-09	9.28E-14	1.18E-09	3.58E-12	9.08E-10	9.12E-10
Solid waste building	8.75E-11	8.86E-10	6.88E-10	2.80E-12	1.66E-09	6.19E-14	7.84E-10	2.39E-12	6.06E-10	6.08E-10
Cooling tower	1.46E-10	1.48E-09	1.15E-09	4.66E-12	2.77E-09	1.03E-13	1.31E-09	3.98E-12	1.01E-09	1.01E-09
RCC evaporator	9.11E-11	9.23E-10	7.17E-10	2.91E-12	1.73E-09	6.45E-14	8.16E-10	2.49E-12	6.31E-10	6.33E-10
Incinerator	3.64E-11	3.69E-10	2.87E-10	1.17E-12	6.94E-10	2.58E-14	3.27E-10	9.96E-13	2.52E-10	2.53E-10
Concrete and asphalt	1.24E-08	1.26E-07	9.78E-08	3.98E-10	2.37E-07	8.80E-12	1.11E-07	3.40E-10	8.61E-08	8.64E-08
Contaminated material	7.85E-11	7.95E-10	6.17E-10	2.51E-12	1.49E-09	5.55E-14	7.03E-10	2.14E-12	5.43E-10	5.46E-10
Chipped Pallets	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table E-24 Radiological Impacts for Alternative 2 by Material Type for Rail Transport

	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
Material Type	**On-Link**	**Off-Link**	**Residents Near Stops**	**Public at Stops**	**Total Public**	**Resident Near Route**	**Resident Near Stop**	**Rail Crew in Transit**	**Rail Crew at Stops**	**Crew Total**
Subsoils and Bedrock										
Contaminated materials	1.26E-08	1.28E-07	9.92E-08	4.03E-10	2.40E-07	8.92E-12	1.13E-07	3.44E-10	8.73E-08	8.76E-08
TOTAL	**6.56E-08**	**6.65E-07**	**5.16E-07**	**2.10E-09**	**1.25E-06**	**4.64E-11**	**5.88E-07**	**1.79E-09**	**4.54E-07**	**4.56E-07**

Table E-25 Increased Risk of LCF to the MEI for Alternatives 2 and 3

Mode/Receptor	Alternative 2 All Off-site Disposal (increased risk of LCF)	Alternative 3 Partial Off-site Disposal (increased risk of LCF)
Rail		
Resident near rail route	4.64E-11	NA
Resident near a rail stop	5.88E-07	NA
Truck		
Truck driver – **MEI**	NA	5.04E-07[a]
Resident near truck route	NA	2.47E-11
Resident near truck stop	NA	2.20E-08

NA = Not Applicable.
[a] Assumes 18 truck crews of two drivers each.

Table E-26 Collective and Individual Impacts from the Maximum Reasonably Foreseeable Accident

Radionuclide	Rural Population (LCFs)	Urban Population (LCFs)	Individual (increased risk of LCF)
U-234	1.28E-09	5.09E-08	4.84E-08
U-235	5.18E-10	2.07E-08	2.01E-09
U-238	1.03E-09	4.10E-08	4.02E-08
Ra-226	1.07E-10	4.26E-09	3.24E-09
Th-230	2.29E-07	9.14E-06	1.08E-07
Total	2.32E-07	9.26E-06	2.02E-07

Table E-27 Partial Off-site Disposal Alternative: Radiological Impacts for Disposition by Truck Transport of Contaminated Material from SFC, by Destination

	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
Destination	On-Link	Off-Link	Residents Near Stops	Public at Stops	Total Public Dose	Resident Near Route	Resident Near Stop	Truck Crew in Transit	Truck Crew at Stops	Crew Total
Clive, Utah	9.29E-07	3.76E-07	9.20E-09	2.87E-06	4.19E-06	2.47E-11	2.20E-08	1.62E-05	1.99E-06	1.81E-05
Blanding, Utah	1.23E-06	5.39E-07	1.28E-08	4.78E-06	6.56E-06	2.47E-11	1.62E-08	1.95E-05	2.35E-06	2.18E-05
Andrews, Texas	9.47E-07	1.96E-07	6.35E-09	3.21E-06	4.36E-06	2.47E-11	1.04E-08	1.32E-05	1.52E-06	1.47E-05

Table E-28 Off-site Disposal Alternative: Radiological Impacts for Disposition by Rail Transport of Contaminated Material from SFC, by Destination

	General Population (LCF)					MEI (Increased Risk of LCF)		Workers (LCF)		
Destination	On-Link	Off-Link	Residents Near Stops	Public at Stops	Total Public Dose	Resident Near Route	Resident Near Stop	Rail Crew in Transit	Rail Crew at Stops	Crew Total
Clive, Utah	6.56E-08	6.65E-07	5.16E-07	2.10E-09	1.25E-06	4.64E-11	5.88E-07	1.79E-09	4.54E-07	4.56E-07
Blanding, Utah	5.93E-08	6.27E-07	4.43E-07	2.10E-09	1.13E-06	4.64E-11	5.11E-07	1.56E-09	4.54E-07	4.56E-07
Andrews, Texas	4.33E-08	5.52E-07	3.51E-07	2.10E-09	9.48E-07	4.64E-11	2.96E-07	9.03E-10	4.54E-07	4.55E-07

Table E-29 Increased Risk to Individuals of Contracting an LCF, by Alternative and Destination

	Off-site Disposal Alternative (increased risk of LCF)	Partial Off-site Disposal Alternative (increased risk of LCF)	Off-site Disposal Alternative (increased risk of LCF)	Partial Off-site Disposal Alternative (increased risk of LCF)	Off-site Disposal Alternative (increased risk of LCF)	Partial Off-site Disposal Alternative (increased risk of LCF)
Destination	**Clive, UT**	**Clive, UT**	**Blanding, UT**	**Blanding, UT**	**Andrews, TX**	**Andrews, TX**
Rail Impacts						
Resident near Rail Route	4.64E-11	NA	4.64E-11	NA	4.64E-11	NA
Resident near a Rail Stop	5.88E-07	NA	5.11E-07	NA	2.96E-07	NA
Truck Impacts						
Truck Driver – MEI[a]	NA	5.04E-07	NA	6.06E-07	NA	4.08E-07
Resident near Truck Route	NA	2.47E-11	NA	2.47E-11	NA	2.47E-11
Resident near Truck Stop	NA	2.20E-08	NA	1.62E-08	NA	1.04E-08

[a] Assumes 18 truck crews of two drivers each

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APPENDIX F

COST ANALYSIS

Table F-1 No Action Alternative

Activity/Cost Element	Direct Cost ($000s)	Notes/Assumptions/Parameters			
1. Long term site control fund[1]	$18,420				
		Derivation of Long-term Annual Maintenance Costs			
		Staff	No.		**2007[2]**
		Manager/Engineer	0.25	FTE	$31,276
		Technicians	2	FTE	$72,978
		Security Guards	2	FTE	$83,404
		Administration	0.25	FTE	$10,425
		O&M			
		Utilities			$10,425
		Analytical Cost			$52,127
		Materials, supplies			$52,127
		NRC fees			$52,127
		Mowing			
		6 mowings (96 h @ $36.5)	96	$36.49	$3,503
		Total:			$368,394
2. Long-term Groundwater Recovery and Treatment	$1,355	13 yrs. @ $104,250/yr. (undiscounted)			
Total Cost	**$19,775**				

Standard construction work units of measurement used in all tables

Notes:

1 The long-term site control fund represents the capitalized value of the annual long-term maintenance cost of $368,394. The value of the fund size was calculated by dividing the annual amount by a 2% discount rate ($368,394 / 0.02 =$18,419,700). The annual long-term maintenance costs include annual sampling of 25 monitoring wells and analysis for uranium, nitrate and arsenic, preparation of an annual report, and mowing six times per year.

2 2007$ updated using November 2007 Consumer Price Index, U.S. Bureau of Labor Statistics.

Table F-2 Alternative 1: On-Site Disposal of Contaminated Materials (the Licensee's Proposed Action)

Estimated Costs for On-Site Disposal		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor Mobilization and demobilization	$694	5% of lines, 4, 5, 6, 7, 8, 9 and 11.
4. Monitoring Well Removal and Replacement	$–	Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Cost for Placing Super Sacks in Disposal Cell	$50	
7. Other Sludge, Removal, Treatment and On-Site Disposal	$3,122	See note (4)
8. Soil Remediation	$1,716	See Table F-2b
9. Building and Equipment Demolition	$3,994	See note (5)
10. Termination Survey	$391	See note (6)
11. Site Restoration	$1,931	See note (7)
12. Groundwater Remediation	$1,199	See note (8)
13. Engineering Construction Management	$2,246	15% of lines 3 through 11.
14. Post-Closure Monitoring Program	$84	See note (9)
15. SFC Staff	$7,612	See note (10)
16. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
17. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Subtotal:	$29,623	
Contingency (@ 10% of direct costs)	$2,962	
Grand Total:	**$32,585**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement of other sludges in the cell (1,433,015 cu-ft @ $2.179/cu-ft.). Sum of non-raffinate sludge and sediments from Material Characteristics Table F-2a.

(5) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(6) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(7) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(8) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(9) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(10) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-2a Material Characteristics Sheet

Description	Volume (cubic feet)	In Cell Volume (cubic feet)	Density g/cm^3	Total Weight (lbs)	Total Weight (tons)
Sludges and Sediments					
Raffinate sludge	1,064,000	247,009	1.360	2.10E+07	10,478
Pond 2 residual materials	635,000	762,000	1.710	8.13E+07	40,640
Emergency basin sediment	14,600	14,600	1.511	1.38E+06	688
North ditch sediment	20,770	20,770	1.511	1.96E+06	979
Sanitary lagoon sediment	10,365	10,365	1.511	9.77E+05	488
Fluoride holding basin #1	171,400	171,400	1.540	1.65E+07	8,233
Fluoride holding basin #2	186,000	186,000	1.540	1.79E+07	8,934
Fluoride settling basins and clarifier	114,300	114,300	1.540	1.10E+07	5,490
Buried calcium fluoride	96,380	96,380	1.540	9.26E+06	4,629
Buried fluoride holding basin #1	57,200	57,200	1.540	5.49E+06	2,747
subtotal:	**2,370,015**	**1,680,024**	**15**	**166,613,236**	**83,307**
Liner Soils and Subsoils					
Clarifier liners	332,400	332,400	1.760	3.65E+07	18,247
Calcium fluoride basin liner	95,285	95,285	1.760	1.05E+07	5,231
Emergency basin soils	162,500	162,500	1.760	1.78E+07	8,920
North Ditch soils	87,500	87,500	1.760	9.61E+06	4,803
Sanitary Lagoon liner	56,356	56,356	1.760	6.19E+06	3,094
subtotal:	**734,041**	**734,041**	**9**	**80,588,001**	**40,294**
Buried Material/Drums					
Pond 1 spoils pile	437,400	437,400	1.760	4.80E+07	24,010
Interim storage cell	154,887	154,887	1.760	1.70E+07	8,502
Solid waste burials (No. 1)	43,000	43,000	1.760	4.72E+06	2,360
Solid waste burials (No. 2)	8,100	8,100	1.760	8.89E+05	445
DUF4 drummed container trash	2,200	2,200	0.545	7.48E+04	37
Other drummed container trash	5000	5000	0.545	1.70E+05	85
Empty contam. Drum	2,000	2,000	0.883	1.10E+05	55
subtotal:	**652,587**	**652,587**	**9**	**70,990,325**	**35,495**
Structural Materials[1]					
Main process building	2,178,000	436,600	3.204	8.73E+07	43,630
Solvent extraction building	180,000	36,000	3.204	7.20E+06	3,598
DUF4 building	281,000	56,200	3.204	1.12E+07	5,616
ADU/Misc digestion building	75,000	2,500	3.204	5.00E+05	250
Laundry building	12,500	3,000	3.204	6.00E+05	300
Centrifuge building	15,000	6,000	3.204	1.20E+06	600

Table F-2a Material Characteristics Sheet

Description	Volume (cubic feet)	In Cell Volume (cubic feet)	Density g/cm^3	Total Weight (lbs)	Total Weight (tons)
Bechtel building	27,000	5,400	3.204	1.08E+06	540
Solid waste building	18,000	3,600	3.204	7.20E+05	360
Cooling tower	30,000	6,000	3.204	1.20E+06	600
RCC evaporator	18,750	3,750	3.204	7.49E+05	375
Incinerator	7,500	1,500	3.204	3.00E+05	150
Concrete and asphalt	511,795	511,795	3.204	1.02E+08	51,144
Scrap metal	100,000	50,000	0.883	2.75E+06	1,377
Chippel Pallets	3,000	3,000	0.300	5.61E+04	28
subtotal:	**3,457,545**	**1,125,345**	**40**	**217,131,023**	**108,566**
Subsoils and Bedrock					
Contaminated materials	811,685	811,685	1.760	89,112,285.89	44,556
TOTAL	**8,025,873**	**5,003,682**		**624,434,871.35**	**312,217.44**

Standard construction work units of measurement used in all tables

Notes;

[1] Existing volume values are for existing building volumes. In-cell volumes are estimated at 20% of built structure.

Table F-2b Soil Remediation and Consolidated Debris Cost (Alternatives 1 and 3)

Derivation of Soil Remediation and Consolidated Debris Costs			
Waste Element	**Cubic Feet of Material**	**Unit Cost per cubic foot 2007 $**	**Total Cost**
Contaminated Subsoils & Bedrock	811,685	$0.782	$634,663
DUF4 Trash Drums	2,200	$12.511	$27,523
CaF2 Basin Clay Liners	95,290	$0.688	$65,567
Solid Waste Burials	51,100	$1.522	$77,780
Pond 1 Spoils Pile	437,000	$0.688	$300,691
Interim Soils Storage Cell	154,887	$0.688	$106,575
Clarifier Clay Liners	332,400	$0.688	$228,718
Drummed LLW	5,000	$12.511	$62,553
Sanitary Lagoon Soil	56,400	$0.688	$38,808
Emergency Basin Soil	162,500	$0.688	$111,813
North Ditch Soil	87,500	$0.688	$60,207
Crushed Drums	2,000	$0.688	$1,376
Total	2,197,962		$1,716,273

Table F-3 Alternative 2, Option 1: Off-Site Disposal of All Contaminated Materials

Transport of all materials by rail to EnergySolutions (Clive, Utah)

Estimated Direct Costs for Off-Site Disposal to EnergySolutions (Alternative 2-1)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$569	5% of lines, 4, 5, 6, 7, 8, 9 and 11.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure		Not required for the off-site disposal option
6. Dewater Raffinate Sludge		Task Complete
7. Other Sludge, Removal & Treatment & Loading for Transport	$3,122	See note (3)
8. Soil Remediation	$3,877	See Table F-3a
9. Building and Equipment Demolition	$3,994	See note (4)
10. Shipping and Off-Site Disposal	$177,191	See note (5)
11. Termination Survey	$391	See note (6)
12. Site Restoration	$1,931	See note (7)
13. Groundwater Remediation	$1,199	See note (8)
14. Engineering Construction Management	$28,661	15% of lines 3 through 12.
15. SFC Staff	$7,612	See note (9)
16. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$231,258	
Contingency (@ 10% of direct costs)	$23,126	
Grand Total:	**$254,384**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Volume 1,433,015 cu-ft @ $2.179/cu-ft (sum of non-raffinate sludge and sediments from Material Characteristics Table F-2a).

(4) From SFC Environmental Report.

(5) Calculated by multiplying 463,850 tons times $382/ton (cost quote EnergySolutions 2007).

(6) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(7) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(8) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(9) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-3a Soil Remediation and Consolidated Debris Costs (Alternative 2)

Derivation of Soil Remediation and Consolidated Debris Costs			
Waste Element	**Cubic Feet of Material**	**Unit Cost/ cubic foot 2007 $**	**Total Cost**
DUF4 Trash Drums	2,200	$12.563	$27,638
Subsoils and Bedrock	3,574,000	$0.782	$2,794,541
CaF2 Basin Clay Liners	95,290	$0.688	$65,567
Solid Waste Burials	51,100	$1.522	$77,780
Pond 1 Spoils Pile	437,000	$0.688	$300,691
Interim Soils Storage Cell	154,887	$0.688	$106,575
Clarifier Clay Liners	332,400	$0.688	$228,718
Drummed LLW	5,000	$12.563	$62,813
Sanitary Lagoon Soil	56,400	$0.688	$38,808
Emergency Basin Soil	162,500	$0.688	$111,813
North Ditch Soil	87,500	$0.688	$60,207
Crushed Drums	2,000	$0.688	$1,376
Total	4,960,277		3,876,526

Table F-4 Alternative 2, Option 2: Off-Site Disposal of All Contaminated Materials

Transport of all materials by rail to WCS (Andrews, Texas)

Estimated Direct Costs for the Off-Site Disposal to WCS (Alternative 2-2)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$569	5% of lines, 4, 5, 6, 7, 8, 9 and 11.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure		Not required for the off-site disposal option
6. Dewater Raffinate Sludge		Task Complete
7. Other Sludge, Removal & Treatment & Loading for Transport	$3,122	See note (3)
8. Soil Remediation	$3,877	See Table F-3a
9. Building and Equipment Demolition	$3,994	See note (4)
10. Shipping and Off-Site Disposal	$89,253	See note (5)
11. Termination Survey	$391	See note (6)
12. Site Restoration	$1,931	See note (7)
13. Groundwater Remediation	$1,199	See note (8)
14. Engineering Construction Management	$15,471	15% of lines 3 through 12.
15. SFC Staff	$7,612	See note (9)
16. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$130,130	
Contingency (@ 10% of direct costs)	$13,013	
Grand Total:	**$143,143**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS

(3) Volume 1,433,015 cu-ft @ $2.179/cu-ft (sum of non-raffinate sludge and sediments from Material Characteristics Table F-2a).

(4) From SFC Environmental Report.

(5) Calculated based on scaling the EnergySolutions price quote by the relative rail distances between WCS and EnergySolutions, Inc. Calculated using the ratio of the WCS rail distance (km) to the EnergySolutions rail distance (km); equal to: (1221 km / 2424 km) x (382/ton) x (463,850 tons).

(6) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(7) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(8) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(9) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-5 Alternative 3, Option 1-1: Partial Off-site Disposal of Contaminated Materials

Raffinate sludge transported by truck to White Mesa (Blanding, Utah) and other sludges and sediments transported by truck to Pathfinder Mines Corp. (PMC, Mills, Wyoming).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-1-1)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport of raffinate sludge to White Mesa	$1,985	See note (5)
8b. Raffinate sludge processing cost at White Mesa	$1,310	= [10,478 tons x $125/ton processing cost].
8c. Transport of other sludges and sediments to PMC	$407	See note (6)
8d. Disposal of other sludges and sediments at PMC	$455	= [2155 tons x $210.9/ton PMC disposal cost]
8e. Recovered Materials Rebate (-) Raffinate Sludge	$(738)	See note (7)
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (8)
11. Termination Survey	$391	See note (9)
12. Site Restoration	$1,931	See note (10)
13. Groundwater Remediation	$1,199	See note (11)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (12)
16. SFC Staff	$7,612	See note (13)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
19. White Mesa license amendment	$100	
Total Direct Cost:	$32,961	
Contingency (@ 10% of direct costs)	$3,296	
Grand Total:	**$36,257**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier transport price quotes in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean transport price quote of $189.4/ton]. Mean transport price reflects quotes received from seven carriers.

(6) See Appendix F Table F-17 for mean carrier transport price quote in $/ton by final destination. Table value = 2,155 tons of sediment (includes Emergency Basin + North Ditch + Sanitary Lagoon) going 1675 km using $189/ton. Mean transport price reflects quotes received from seven carriers.

(7) Reflects potential rebate provided by mill for market value of recovered uranium constituents using March 2008 price for uranium. See Table F-18.

(8) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(9) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(10) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(11) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(12) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(13) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-6 Alternative 3, Option 1-2: Partial Off-site Disposal of Contaminated Materials
Raffinate sludge transported by truck to White Mesa (Blanding, Utah) and other sludges and sediments transported by truck to EnergySolutions (Clive, Utah).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-1-2)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport raffinate sludge to White Mesa	$1,985	See note (5)
8b. Raffinate sludge processing cost at White Mesa	$1,310	Value = [10,478 tons of raffinate sludge x $125/ton processing cost].
8c. Transport other sludges and sediments to EnergySolutions	$517	See note (6)
8d. Disposal of other sludges and sediments at EnergySolutions	$493	= $228.9/ton disposal cost x 2155 tons
8e. Recovered Materials Rebate (-) Raffinate Sludge	$(738)	See note (7)
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (8)
11. Termination Survey	$391	See note (9)
12. Site Restoration	$1,931	See note (10)
13. Groundwater Remediation	$1,199	See note (11)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12.(less 8)
15. Post-Closure Monitoring Program	$84	See note (12)
16. SFC Staff	$7,612	See note (13)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
19. White Mesa license amendment	$100	
Total Direct Cost:	$33,109	
Contingency (@ 10% of direct costs)	$3,311	
Grand Total:	**$36,420**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.
(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.
(3) Cell design included in 2006 Reclamation Plan.
(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).
(5) See Appendix F Table F-17 for mean carrier transport price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean price quote of $189.4/ton]. Mean transport price reflects quotes received from seven carriers.
(6) See Appendix F Table F-17 for mean carrier transport price quote in $/ton by final destination. Table value = 2,155 tons of sediment (includes Emergency Basin + North Ditch + Sanitary Lagoon) going 2190 km multiplied times $239.9/ton. Mean transport price reflects quotes received from seven carriers.
(7) Reflects potential rebate provided by mill for market value of recovered uranium constituents using March 2008 price for uranium. See Table F-18
(8) Source: SFC Environmental Report 2006, includes demolition and placement in cell.
(9) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.
(10) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.
(11) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.
(12) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.
(13) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-7 Alternative 3, Option 1-3: Partial Off-site Disposal of Contaminated Materials

Raffinate sludge transported by truck to White Mesa (Blanding, Utah) and other sludges and sediments transported by truck to WCS (Andrews, Texas).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-1-3)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport raffinate sludge to White Mesa	$1,985	See note (5)
8b. Raffinate sludge processing cost at White Mesa	$1,310	= [10,478 tons x $125/ton processing cost]
8c. Transport other sludges and sediments to WCS	$284	See note (6)
8d. Disposal of other sludges and sediments at WCS	$231	= $107/ton disposal cost x 2155 tons.
8e. Recovered Materials Rebate (-) Raffinate Sludge	$(738)	See note (7)
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (8)
11. Termination Survey	$391	See note (9)
12. Site Restoration	$1,931	See note (10)
13. Groundwater Remediation	$1,199	See note (11)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8)
15. Post-Closure Monitoring Program	$84	See note (12)
16. SFC Staff	$7,612	See note (13)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
19. White Mesa license amendment	$100	
Total Direct Cost:	$32,613	
Contingency (@ 10% of direct costs)	$3,261	
Grand Total:	**$35,875**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.
(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.
(3) Cell design included in 2006 Reclamation Plan.
(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).
(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean transport price quote of $189.4/ton]. Mean transport price reflects quotes received from seven carriers.
(6) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [2155 tons of raffinate sludge x mean transport price quote of $131.6/ton]. Mean transport price reflects quotes received from seven carriers.
(7) Reflects potential rebate provided by mill for market value of recovered uranium constituents using March 2008 price for uranium. See Table F-18
(8) Source: SFC Environmental Report 2006, includes demolition and placement in cell.
(9) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.
(10) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.
(11) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater as necessary.
(12) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.
(13) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-8 Alternative 3, Option 2-1: Partial Off-Site Disposal of Contaminated Materials

Raffinate sludge transported by truck to Rio Algom (Grants, New Mexico) and other sludges and sediments transported by truck to Pathfinder Mines Corp. (Mills, Wyoming).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-2-1)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport of raffinate sludge to Rio Algom	$1,638	See note (5)
8b. Disposal of raffinate sludge at Rio Algom	$2,096	= [10,478 x $200/ton disposal cost]
8c. Transport of other sludges and sediments to PMC	$407	See note (6)
8d. Disposal of other sludges and sediments at PMC	$455	= $210.9/ton disposal cost x 2155 tons
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (7)
11. Termination Survey	$391	See note (8)
12. Site Restoration	$1,931	See note (9)
13. Groundwater Remediation	$1,199	See note (10)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (11)
16. SFC Staff	$7,612	See note (12)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$34,038	
Contingency (@ 10% of direct costs)	$3,404	
Grand Total:	**$37,441**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean price quote of $156.3/ton]. Mean transport price reflects quotes received from seven carriers.

(6) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Value = 2,155 tons of sediment (includes Emergency Basin + North Ditch + Sanitary Lagoon) going 1675 km using $189/ton. Mean transport price reflects quotes received from seven carriers.

(7) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(8) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(9) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(10) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater as necessary.

(11) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(12) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-9 Alternative 3, Option 2-2: Partial Off-Site Disposal of Contaminated Materials

Raffinate sludge transported by truck to Rio Algom (Grants, New Mexico) and other sludges and sediments transported by truck to EnergySolutions (Clive, Utah).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-2-2)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport raffinate sludge to Rio Algom	$1,638	See note (5)
8b. Disposal of raffinate sludge at Rio Algom	$2,096	= [10,478 x $200/ton disposal cost]
8c. Transport other sludges and sediments to EnergySolutions	$517	See note (6)
8d. Disposal of other sludges and sediments at EnergySolutions	$493	= $228.9/ton disposal cost x 2155 tons.
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (7)
11. Termination Survey	$391	See note (8)
12. Site Restoration	$1,931	See note (9)
13. Groundwater Remediation	$1,199	See note (10)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (11)
16. SFC Staff	$7,612	See note (12)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$34,186	
Contingency (@ 10% of direct costs)	$3,419	
Grand Total:	**$37,605**	

Standard construction work units of measurement used in all tables

Notes: details may not add exactly to grand total due to independent rounding.

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.
(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.
(3) Cell design included in 2006 Reclamation Plan.
(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).
(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean price quote of $156.3/ton]. Mean transport price reflects quotes received from seven carriers.
(6) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = 2,155 tons of sediment (includes Emergency Basin + North Ditch + Sanitary Lagoon) going 2190 km using $239.9/ton. Mean transport price reflects quotes received from seven carriers.
(7) Source: SFC Environmental Report 2006, includes demolition and placement in cell.
(8) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.
(9) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.
(10) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.
(11) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.
(12) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-10 Alternative 3, Option 2-3: Partial Off-Site Disposal of Contaminated Materials

Raffinate sludge transported by truck to Rio Algom (Grants, New Mexico) and other sludges and sediments transported by truck to WCS (Andrews, Texas).

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-2-3)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport raffinate sludge to Rio Algom	$1,638	See note (5)
8b. Disposal of raffinate sludge at Rio Algom	$2,096	= [10,478 x $200/ton disposal cost]
8c. Transport other sludges and sediments to WCS	$284	See note (6)
8d. Disposal of other sludges and sediments at WCS	$231	= $107/ton disposal cost x 2155 tons.
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (7)
11. Termination Survey	$391	See note (8)
12. Site Restoration	$1,931	See note (9)
13. Groundwater Remediation	$1,199	See note (10)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (11)
16. SFC Staff	$7,612	See note (12)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$33,690	
Contingency (@ 10% of direct costs)	$3,369	
Grand Total:	**$37,059**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge x mean price quote of $156.3/ton]. Mean transport price reflects quotes received from seven carriers.

(6) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = 2,155 tons of sediment (includes Emergency Basin + North Ditch + Sanitary Lagoon) going 1038 km using $131.6/ton. Mean reflects quotes received from seven carriers.

(7) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(8) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(9) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(10) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(11) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(12) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-11 Alternative 3, Option 3-1: Partial Off-Site Disposal of Contaminated Materials

Transport raffinate sludge and other sludges and sediments via truck to EnergySolutions (Clive, Utah)

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-3-1)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport of raffinate sludge and other sludges and sediments to EnergySolutions	$3,030	See note (5)
8b. Disposal of raffinate sludge and other sludges and sediments at EnergySolutions	$2,891	= [10,478+2155] x $228.9/ton disposal cost
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (6)
11. Termination Survey	$391	See note (7)
12. Site Restoration	$1,931	See note (8)
13. Groundwater Remediation	$1,199	See note (9)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (10)
16. SFC Staff	$7,612	See note (11)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$35,364	
Contingency (@ 10% of direct costs)	$3,536	
Grand Total:	**$38,900**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge + 2155 tons of sediment] x mean price quote of $239.9/ton]. Mean transport price reflects quotes received from seven carriers.

(6) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(7) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(8) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(9) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(10) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(11) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-12 Alternative 3, Option 3-2: Partial Off-Site Disposal of Contaminated Materials

Transport raffinate sludge and other sludges and sediments via truck to WCS (Andrews, Texas)

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-3-2)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport of raffinate sludge and other sludges and sediments to WCS	$1,662	See note (5)
8b. Disposal of raffinate sludge and other sludges and sediments at WCS	$1,351	= [10,478+2155] x $107/ton disposal cost
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (6)
11. Termination Survey	$391	See note (7)
12. Site Restoration	$1,931	See note (8)
13. Groundwater Remediation	$1,199	See note (9)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (10)
16. SFC Staff	$7,612	See note (11)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @$104,250/year
Total Direct Cost:	$32,456	
Contingency (@ 10% of direct costs)	$3,246	
Grand Total:	**$35,701**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge + 2155 tons of sediment] x mean price quote of $131.6/ton]. Mean transport price reflects quotes received from seven carriers.

(6) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(7) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.

(8) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(9) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(10) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(11) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-13 Alternative 3, Option 3-3: Partial Off-Site Disposal of Contaminated Materials

Transport raffinate sludge and other sludges and sediments via truck to Pathfinder Mines Corp. (PMC, Mills, Wyoming)

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-3-3)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport of raffinate sludge and other sludges and sediments to PMC	$2,388	See note (5)
8b. Disposal of raffinate sludge and other sludges and sediments at PMC	$2,665	= [10,478+2155] x $210.9/ton disposal cost
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (6)
11. Termination Survey	$391	See note (7)
12. Site Restoration	$1,931	See note (8)
13. Groundwater Remediation	$1,199	See note (9)
14. Engineering Construction Management	$2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (10)
16. SFC Staff	$7,612	See note (11)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
Total Direct Cost:	$34,495	
Contingency (@ 10% of direct costs)	$3,449	
Grand Total:	**$37,944**	

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.

(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.

(3) Cell design included in 2006 Reclamation Plan.

(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).

(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge + 2155 tons of sediment] x mean price quote of $189/ton]. Mean transport price reflects quotes received from seven carriers.

(6) Source: SFC Environmental Report 2006, includes demolition and placement in cell.

(7) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment/NRC confirmation.

(8) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.

(9) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.

(10) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.

(11) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-14 Alternative 3, Option 4: Partial Off-Site Disposal of Contaminated Materials
Transport both raffinate sludge and other sludges and sediments via truck to White Mesa (Blanding, Utah)

Estimated Direct Costs for the Partial Off-Site Disposal Alternative (Alternative 3-4)		
Activity/Cost Element	**2007 $ (000s)**	**Note/Comment**
1. Complete Reclamation Plan and Supporting Documents	$457	See note (1)
2. NRC Charges for Reclamation Plan Review, EIS Preparation	$900	See note (2)
3. Contractor mobilization and demobilization	$687	5% of lines, 4, 5, 6, 7, 9, 10 and 12.
4. Monitoring Well Removal and Replacement		Task Complete
5. Disposal Cell Construction / Closure	$3,073	See note (3)
6. Other Sludge, Removal, Treatment and On-Site Disposal	$3,023	See note (4)
7. Dewater raffinate sludge		Task Complete
8a. Transport raffinate sludge and other sludges and sediments to White Mesa	$2,393	See note (5)
8b. Raffinate sludge and other sludges and sediments processing cost at White Mesa	$1,579	= [10,478 + 2155] x $125/ton processing cost
8c. Recovered Materials Rebate (-) Raffinate Sludge + Other	$(773)	See note (6)
9. Soil Remediation and On-Site Disposal	$1,716	See Table F-2b
10. Building and Equipment Demolition	$3,994	See note (7)
11. Termination Survey	$391	See note (8)
12. Site Restoration	$1,931	See note (9)
13. Groundwater Remediation	$1,199	See note (10)
14. Engineering Construction Management	2,222	15% of lines 3 through 12 (less 8).
15. Post-Closure Monitoring Program	$84	See note (11)
16. SFC Staff	$7,612	See note (12)
17. Long-Term Site Control Fund	$798	Per 10 CFR 40, Appendix A, Criterion 10 ($250K, 1978 escalated to 2007 $).
18. Long-term Groundwater Recovery and Treatment	$1,355	13 years @ $104,250/year
19. White Mesa License Amendment	$100	
Total Direct Cost:	$32,741	
Contingency (@ 10% of direct costs)	$3,274	
Grand Total:	**$36,015**	

Standard construction work units of measurement used in all tables

Notes:

(1) Includes responses to RAIs and revisions to the Reclamation Plan, groundwater Corrective Action Plan and preparation of an Alternate Concentration Limit Application.
(2) Includes review and approval of Reclamation Plan and groundwater Corrective Action Plan and completion of EIS.
(3) Cell design included in 2006 Reclamation Plan.
(4) Excavation, treatment and placement in the cell of sludges not being shipped off-site (1,387,280 cu-ft @ $2.179/cu-ft, see Materials Characteristics Table F-2a).
(5) See Appendix F Table F-17 for mean carrier price quote in $/ton by final destination. Table value = [10,478 tons of raffinate sludge + 2155 tons of sediment] x mean price quote of $189.4/ton]. Mean transport price reflects quotes received from seven carriers.
(6) Reflects potential rebate provided by mill for market value of recovered uranium constituents using current price for uranium. See Table F-19. Includes uranium recovered from both raffinate sludge and other sediments and sludge
(7) Source: SFC Environmental Report 2006, includes demolition and placement in cell.
(8) 2000 soil samples @ $100 each, plus gamma walkover survey 500 hours @ $50/hr, plus $150K assessment / NRC confirmation.
(9) Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 17,500,000 cu-ft of dike material into impoundments at $0.074 per cu-ft, grading 83 acres @ $3128/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cu-ft at $0.115/cu-ft) and seeding 124 acres at $534/acre.
(10) $100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of storm water and wastewater, as necessary.
(11) Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first 3 to 5 years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.
(12) SFC at current level of six employees plus management augmentation during decommissioning.

Table F-15 Alternative 3, Comparison of Total Transport Costs per Load

Carrier	Total Cost Per Load [1] White Mesa Blanding, UT	Energy Solutions Clive, UT	WCS Andrews, TX	PMC, Mills, WY	Rio Algom, Grants, NM
Carrier 1	$4,942	$6,055	$4,505	$4,610	$4,572
Carrier 2	$2,889	$3,864	$1,679	$2,943	$2,153
Carrier 3	$3,473	$4,569	$2,187	$3,775	$2,552
Carrier 4	$4,783	$6,246	$2,930	$4,796	$3,589
Carrier 5	$2,800	$3,000	$2,150	$2,800	$2,600
Carrier 6	$3,360	$4,464	$2,799	$3,404	$3,307
Carrier 7	$5,289	$6,612	$2,910	$5,122	$3,945
Minimum	$2,800	$3,000	$1,679	$2,800	$2,153
Mean	$3,934	$4,973	$2,737	$3,921	$3,245
Maximum	$5,289	$6,612	$4,505	$5,122	$4,572
Standard Deviation	$1,040	$1,355	$910	$930	$862

Notes:
[1] Price quotes reflect actual quotes received from licensed carriers based on material specifications for the transport of a combined 12,633 tons of raffinate sludge and other sludges and sediments. Rates include base rate and fuel charges.

Figure F-1   Alternative 3, Comparison of Total Transport Costs per Load to Final Destinations

[Min, Mean and Max]

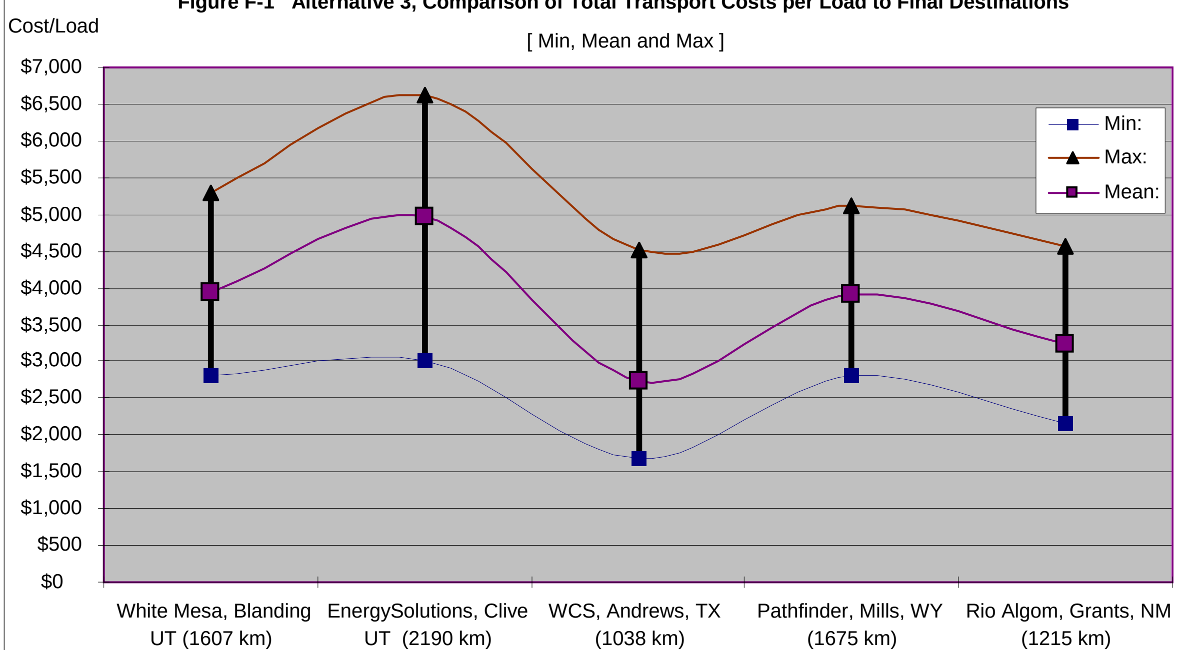


Table F-16 Alternative 3, Total Estimated Transport Costs by Final Destination – Based on One Final Destination – Does Not Reflect Blended Costs of Shipping to Multiple Destinations

Carrier	Maximum Weight/ Payload[1] (lbs)	Tons of Waste/ Payload[2] (tons)	Estim. No. Truck Loads[3]	Total Costs				
				White Mesa Blanding, UT	Energy Solutions Clive, UT	WCS Andrews, TX	PMC, Mills, WY	Rio Algom Grants, NM
1	46,000	22	574	$2,837,889	$3,477,085	$2,587,154	$2,647,189	$2,625,294
2	45,000	22	588	$1,697,215	$2,270,426	$986,306	$1,729,238	$1,264,906
3	43,500	21	609	$2,114,675	$2,781,501	$1,331,613	$2,298,168	$1,553,888
4	42,500	20	624	$2,983,859	$3,896,547	$1,827,871	$2,991,969	$2,238,986
5	45,500	22	581	$1,626,304	$1,742,469	$1,248,769	$1,626,304	$1,510,140
6	40,000	19	665	$2,233,948	$2,967,800	$1,861,225	$2,263,363	$2,198,842
7	43,000	21	616	$3,259,130	$4,074,384	$1,793,198	$3,156,435	$2,431,255
			Min:	$1,626,304	$1,742,469	$986,306	$1,626,304	$1,264,906
			Mean:	$2,393,289	$3,030,030	$1,662,305	$2,387,524	$1,974,759
			Max:	$3,259,130	$4,074,384	$2,587,154	$3,156,435	$2,625,294
			Std Dev:	$669,524	$906,496	$368,483	$629,529	$480,579

Notes and Assumptions:

Assumed Tonnages:
Raffinate sludge 10,478 tons and other sludges and sediments 2,155 tons: Total 12,633 tons

[1] Includes industry estimate of 2,000 lbs for ancillary equipment/pallets, etc.
[2] Tons of Waste = maximum weight per payload less 2,000 lbs for ancillary equipment/pallets, etc. divided by 2,000 lbs per ton.
[3] Total tons of waste (12,633 tons) divided by tons of waste per payload.

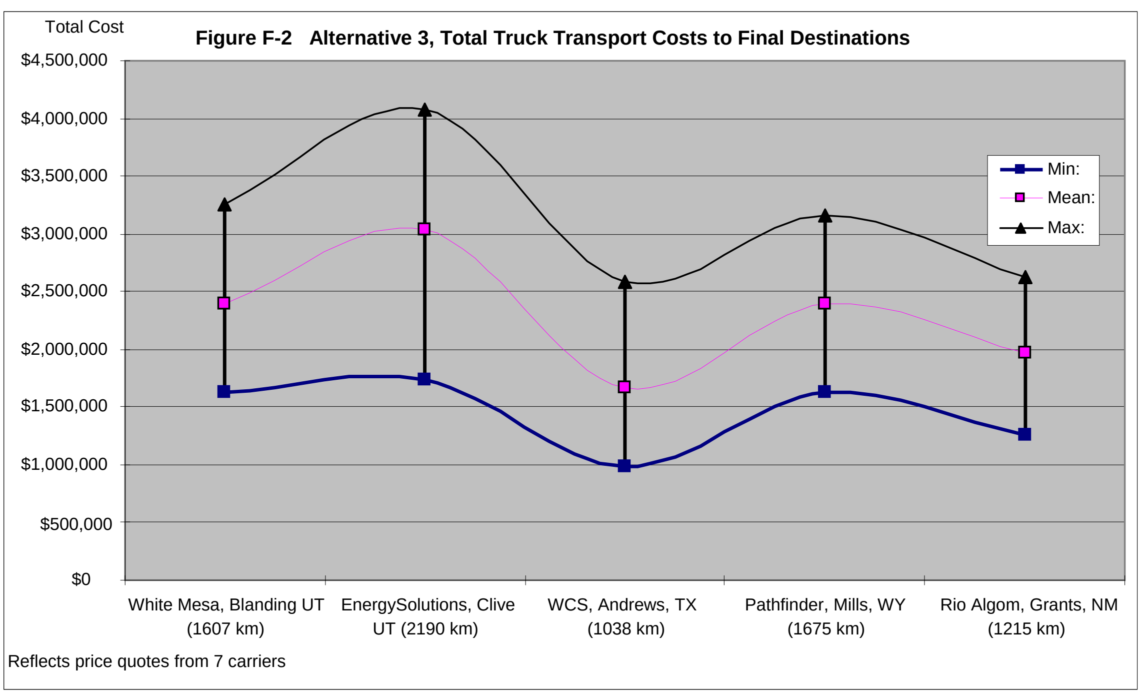
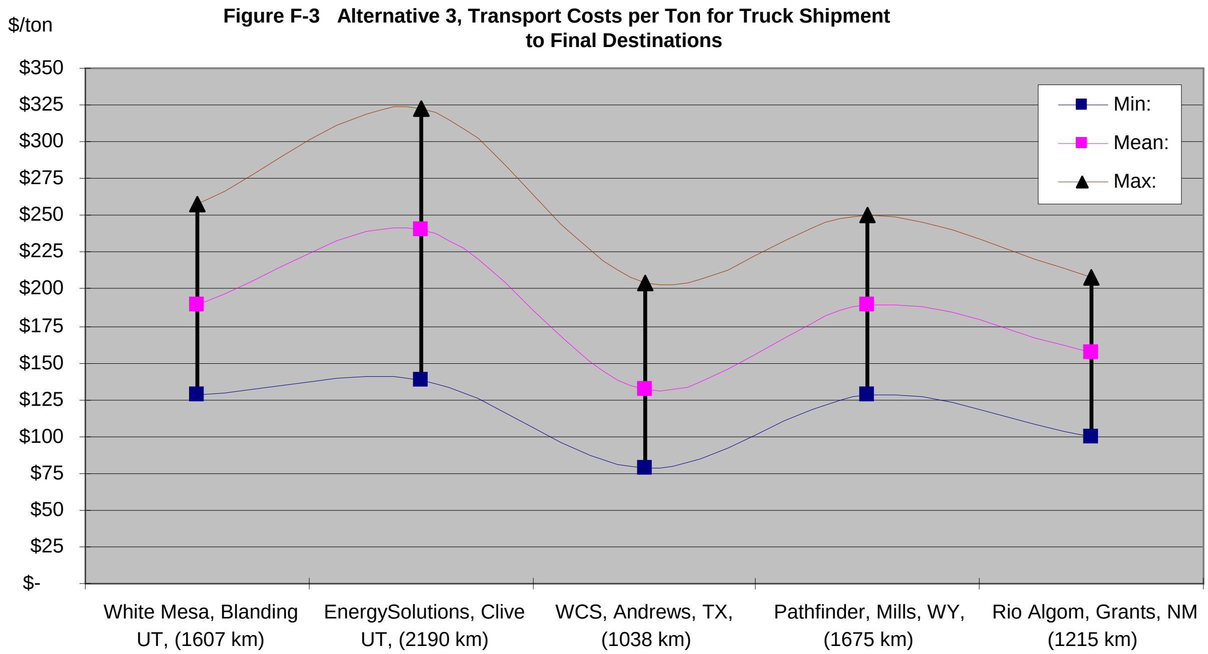


Table F-17 Alternative 3, Comparison of Total Transport Costs per Ton of Waste

Carrier	Total Cost per Ton of Waste				
	White Mesa Blanding, UT	Energy Solutions Clive, UT	WCS Andrews, TX	PMC, Mills, WY	Rio Algom Grants, NM
Carrier 1	$225	$275	$205	$210	$208
Carrier 2	$134	$180	$78	$137	$100
Carrier 3	$167	$220	$105	$182	$123
Carrier 4	$236	$308	$145	$237	$177
Carrier 5	$129	$138	$99	$129	$120
Carrier 6	$177	$235	$147	$179	$174
Carrier 7	$258	$323	$142	$250	$192
Minimum:	$129	$138	$78	$129	$100
Mean:	$189	$240	$132	$189	$156
Maximum:	$258	$323	$205	$250	$208
Standard Deviation:	$51	$67	$42	$46	$41

Figure F-3 Alternative 3, Transport Costs per Ton for Truck Shipment to Final Destinations



Reflects price quotes from 7 carriers

Table F-18 Estimated Potential Rebate for Uranium Recovery from Raffinate Sludge

	Rebate Calculation Elements:	Value	Unit	Source/notes:
A	**Estimated Uranium Content of Sludge**			
1	Estimated tons of raffinate sludge	10,478	tons	Materials volumes and radionuclides 4-11-2007.xls.
2	Uranium content of dewatered raffinate sludge	95,232	lbs	[SFC RAI Response 01_08.pdf], 12/26/07, RE:0752-A, "Raffinate Uranium Content Based on Composite Sample from Each Storage Cell"
3	Estimated Recovery Percentage	75%	%	NRC, 1/23/08, record of Telcon, 9/24/07
4	Recovered uranium from raffinate sludge	71,424	lbs	= row 2 x row 3
5	Recovery rate (in lbs per ton of total feed stock)	6.82	lbs/ton	= row 4 / row 1
B	**Price Assumptions** [1]			See Note 1
6	Weekly Spot Ux U3O8 Price as of March 18, 2008	$70.00	$/lb	http://www.uxc.com/review/uxc_Prices.aspx
7	Estimated lower boundary price	$50.00	$/lb	" ", The Ux Consulting Company, LLC
C	**Revenue Estimate**			
8	Total estimated recoverable uranium x Weekly Spot Price (3/18/08)	$4,999,655	$	= row 4 x row 6
9	Total estimated recoverable uranium x estimated lower boundary price	$3,571,182	$	= row 4 x row 7
D	**Cost Estimate**			
10	Unit processing cost per ton of feed stock	$125	$/ton	NRC, 1/23/08
11	Estimated processing cost	$1,309,750	$	= row 1 x row 10
D	**Estimated Rebate @ 20% of Net Revenue (Net Revenue=Revenue less Processing Costs)**			
12	Estimated rebate using current spot price	$737,981	$	= [row 8 – row 11] x .20. The 20% rebate assumption is based on an industry standard, see Record of Telcon, 9/24/07
13	Estimated rebate using lower boundary price	$452,286	$	= [row 9 – row 11] x .20. The 20% rebate assumption is based on an industry standard, see Record of Telcon, 9/24/07

Notes:
[1] The Ux U3O8 Price is one of only two weekly uranium price indicators that are accepted by the uranium industry, as witnessed by their inclusion in most "market price" sales contracts, i.e., sales contracts with pricing provisions that call for the future uranium delivery price to be equal to the market price at or around the time of delivery.

Table F-19 Estimated Potential Rebate for Uranium Recovery from Raffinate Sludge and Other Sludges and Sediments

	Rebate Calculation Elements:	Value	Unit	Source/notes:
A	**Estimated Uranium Content of Raffinate Sludge**			
1	Estimated tons of raffinate sludge	10,478	tons	Materials volumes and radionuclides 4-11-2007.xls.
2	Uranium content of dewatered raffinate sludge	95,232	lbs	[SFC RAI Response 01_08.pdf], 12/26/07, RE:0752-A, "Raffinate Uranium Content Based on Composite Sample from Each Storage Cell"
3	Estimated Recovery Percentage	75%	%	NRC, 1/23/08, record of Telcon, 9/24/07
4	Recovered uranium from raffinate sludge	71,424	lbs	= row 2 x row 3
5	Recovery rate (in lbs per ton of total feed stock)	6.82	lbs/ton	= row 4 / row 1
	Uranium content of Other Sludges and Sediments			
6	Emergency Basin Sediment + North Ditch Sediment + Sanitary Lagoon sludges and sediments	3,862	U-kg	Materials volumes and radionuclides 4-11-2007.xls.
7	Emergency Basin Sediment + North Ditch Sediment + Sanitary Lagoon sludges and sediments	8,514	lbs	Converted to pounds using 2.2046 lbs/kg.
8	Estimated recovered uranium from sludges and sediments (75% of total)	6,386	lbs	75% of row 7
9	Raw tons of other sludges and sediments	2155	tons	Tons to be processed to extract estimated U-kg
B	**Price Assumptions** [1]			See Note 1
10	Weekly Spot Ux U3O8 Price as of March 18, 2008	$70.00	$/lb	http://www.uxc.com/review/uxc_Prices.aspx
11	Estimated lower boundary price	$50.00	$/lb	" ", The Ux Consulting Company, LLC
C	**Revenue Estimate**			
12	Total estimated recoverable Uranium x Weekly Spot Price (3/18/08)	$5,446,653	$	= [row 4 + row 8] x row 10
13	Total estimated recoverable Uranium x Est. lower boundary price	$3,890,466	$	= [row 4 + row 8] x row 11
D	**Cost Estimate**			
14	Unit processing cost per ton of feed stock	$125	$/ton	NRC, 1/23/08
15	Estimated total processing cost	$1,579,170	$	= [row 1 + row 9] x row 14
D	**Estimated Rebate @ 20% of Net Revenue (Net Revenue=Revenue less Processing Costs)**			
16	Estimated rebate using current spot price	$773,497	$	= [row 12 – row 15] x .20. The 20% rebate assumption is based on an industry standard, see Record of Telcon, 9/24/07
17	Estimated rebate using lower boundary price	$462,259	$	= [row 13 – row 15] x .20. The 20% rebate assumption is based on an industry standard, see Record of Telcon, 9/24/07

Notes:
[1] The Ux U3O8 Price is one of only two weekly uranium price indicators that are accepted by the uranium industry, as witnessed by their inclusion in most "market price" sales contracts, i.e., sales contracts with pricing provisions that call for the future uranium delivery price to be equal to the market price at or around the time of delivery.

APPENDIX G

SEQUOYAH FUELS CORPORATION RAFFINATE DISPOSITION PROGRAMS

G.1 Introduction

The Sequoyah Fuels Corporation (SFC) facility in Gore, Oklahoma, used large quantities of nitric acid in a solvent extraction process for uranium purification and conversion. From this process, significant volumes of process waste liquid (called raffinate) would be generated requiring proper waste management. This untreated raffinate was a solution of nitric acid, metallic salts, and minute quantities of uranium and its long-lived radioactive daughter products, such as the radionuclides Radium-226 and Thorium-230. The raffinate was pumped to holding basins or ponds; however, the net yearly evaporation rate was not sufficient to remove the water component of the untreated raffinate. Quantities of upward to 18,927,000 liters (5 million gallons) per year of raffinate were being generated and stored in the holding ponds from the solvent extraction system used at the SFC facility. Thus, Kerr-McGee Nuclear Corporation (KMNC), the original owner and operator of the uranium conversion facility, recognized that they would have to periodically build additional holding basins to store this raffinate over the lifetime of the facility unless another process for safely disposing of the raffinate could be developed and implemented.

At the beginning of site operations, KMNC initially pursued raffinate disposition through deep-well injection. However, ultimately this was not approved by the regulatory agencies (i.e., the U.S. Nuclear Regulatory Commission (NRC), the U.S. Environmental Protection Agency (EPA), or the State of Oklahoma) under its various phases of development (1969 through 1984). Subsequently, KMNC and then SFC pursued and received approval for using treated raffinate as a liquid fertilizer on the Sequoyah International or SFC-controlled lands. This appendix describes both programs and subsequent impacts to the farmlands where the liquid raffinate was applied as fertilizer.

G.2 Deep-Well Injection Program

In late 1967, prior to the construction of the uranium conversion facility, KMNC began evaluating the option of disposing of the anticipated untreated raffinate into a deep injection well. Following a feasibility study, it was determined that subsurface geological conditions could allow for disposal of fluids via an injection well drilled into the deep bedrock ground-water system, a geological unit called the Arbuckle Formation, which is located from about 408 to 948 meters (1,337 to 3,109 feet) below ground level in the facility area. On September 26, 1969, KMNC began drilling the deep injection well just west of the Main Process Building (SE 1 /4, SW 1 /4, NE 1 /4, Section 21, Township 12N, Range 21 East). Drilling was concluded on October 28, 1969, and the well itself was completed in the next month. Limited injection tests using fresh water began immediately after completion. From such tests, KMNC concluded that the Arbuckle Formation could accept significant volumes of fluids.

In April 1970, KMNC applied to the Atomic Energy Commission (AEC) for an amendment to their license to allow liquid waste disposal through the deep injection well (Wuller, 1970). Six months later, the AEC responded that insufficient information had been provided by KMNC concerning the deep injection well and denied use of the deep injection well. KMNC subsequently requested and was granted AEC approval to withdraw their deep injection well license application without prejudice to a future application until a more detailed study of the Arbuckle Formation was completed.

KMNC subsequently performed an evaluation of the Arbuckle Formation and its groundwater reservoir. The purpose of the study was to define the lateral and vertical boundaries and determine the hydrodynamics of the Arbuckle Reservoir. This evaluation included conducting a long-term pilot injection test into the Arbuckle with fresh water. Also, between 1970 and 1984, four monitoring wells (Well No. 2307, 2331, 2332, and 2333) were installed for purposes of monitoring any potential impact to shallow groundwater associated with the deep injection well.

The second pilot injection test was conducted in June and July of 1971. During this period, 3,165,000 liters (836,143 gallons) of fresh water were injected into the deep injection well over four separate time intervals at rates that varied from 1.6 to 5.7 liters per second (25 to 91 gallons per minute, or gpm). Based upon this study, KMNC reapplied to the AEC on May 10, 1972, for an amendment to their license to allow the use of the deep injection well. In April 1973, the AEC again denied KMNC use of the deep injection well based upon the AEC's conclusion that the Arbuckle Reservoir study did not conclusively prove that the injected liquids could be contained in the reservoir. However, KMNC disputed the ruling by requesting and being granted a hearing before the Atomic Safety and Licensing Board (ASLB).

In October 1973, KMNC presented the deep injection well information to the ASLB. In January 1974, the ASLB supported the AEC and denied KMNC the use of the deep injection well. KMNC conducted no further activities regarding the deep injection well from January 1974 to July 1981.

Between 1973 and 1981, KMNC implemented process changes that resulted in the raffinate being treated and neutralized by reacting the raw raffinate with gaseous ammonia to neutralize the free nitric acid and to precipitate metal ions as hydroxides or hydrated oxides removing a majority of the residual uranium and thorium. KMNC also treated the raffinate with soluble barium to remove radium. The resulting treated raffinate is an ammonia-nitrate solution that was retained in surface impoundments at the facility.

On July 17, 1981, KMNC applied to the Oklahoma State Department of Health (OSDH), Industrial Waste Division, for use of the deep injection well for disposal of treated raffinate as a controlled industrial waste. On July 29, 1982, KMNC also submitted an application to the AEC’s successor, the NRC, requesting a license amendment to permit disposal of treated raffinate into the deep injection well. On October 19, 1982, the OSDH issued a permit to operate the deep injection well. The permit was for a five-year period and allowed injection of up to 18,927,000 liters (5 million gallons) of treated raffinate each year. The injection schedule allowed the injection of 3.8 liters per second (60 gpm) for a period of 60 consecutive days, with no injection during the remainder of the year.

On May 18, 1983, the NRC issued an amended license to authorize injection of treated raffinate into the deep injection well. However, the NRC stipulated that the use of the deep injection well be limited to injection of 18,927,000 liters (5 million gallons) during a pilot test and requested that KMNC submit results of the pilot test to the NRC before additional volumes would be approved for injection.

The pilot test was conducted from June 6, 1983, to August 2, 1983. Approximately 18,927,000 liters (5 million gallons) of treated raffinate were injected at an average rate of 3.8 liters per second (60.7 gpm) (RSA, 1995). During the test, a monitoring program was conducted that included a seismicity study by the University of Oklahoma, a groundwater monitoring program, and pressure monitoring of the injection well during and after the test injection.

With respect to the potential environmental impacts of the pilot test program, the treated raffinate injected in the test was well below the maximum permissible concentrations (MPC) for unrestricted releases as specified by 10 CFR Part 20, Appendix B, Table 2 (in effect at that time) and as shown in Table G-1. The average radionuclide concentrations in the raffinate to be injected were 3.5 percent of the MPC for radium-226, 0.1 percent of the MPC for natural uranium, and less than 0.01 percent of the MPC for thorium-230 (Page, 1983). The radionuclides were also well below the EPA National Primary Drinking Water Standards of 5 pCi/L for radium-226 and 15 pCi/L for gross alpha particle activity (Warner, 1983). The raffinate was shown to be of a better water quality than that found in the Arbuckle Formation (the radium-226 concentration in the Arbuckle Formation is about 1400 pCi/L as shown in Table G-1).

Table G-1 Water Quality Information of Concern to the Deep-Well Injection Program

Item	MPC1 (µCi/ml)	MCL* or TT** Action Level[2]	Untreated Raffinate[5]	Treated Raffinate	Arbuckle Formation
Sample/Report Date	--	--	April 1970	1980	Nov. 1969
Chlorine	--	250 mg/L [3]	--	--	88,300 mg/L
Sodium	--	--	--	--	39,700 mg/L
TDS	--	500 mg/L	--	--	142,000 mg/L
pH	--	6.5 to 8.5 3	Not Given	7.65	--
Copper	--	TT Action Level: 1.3 mg/L [2]	Not Given	5.4 mg/L	--
Molybdenum	--	--	Not Given [5]	9.65 mg/L	--
Nickel	--	--	Not Given [5]	12.0 mg/L	--
Nitrates	--	10 mg/L [2]	Not Given [5]	36,500 mg/L	--
Radium-226	6E-8	5 pCi/L [2]	210 pCi/L [5]	1.07 pCi/L	1,400 pCi/L
Thorium-230	1E-7	15 pCi/L [2, 4]	600 pCi/L [5, 6]	0.065 pCi/L	--
Nat. Uranium	3E-7	30 µg/L [2]	150 pCi/L [5]	45 µg/L	--

1 Source: 10 CFR Part 20, Appendix B, Table 2 and, to convert to pCi/L, multiply by 1.0E+09.
2 Source: EPA, 2002a.
3 Source: EPA, 2002b.
4 The 15 pCi/L limit is for all alpha emitting radionuclides present in the water.
5 Source: Wuller, 1970 and only provides radiological pollutants. It is assumed that the non-radiological pollutants are similar to the quantities given under the Treated Raffinate column.
6 KMNC also would have injected 45,000 pCi/L of Thorium-234. With a half-life of 24.1 days, this radioisotope would decay to below allowable radioactivity limits after 235 days (Wuller, 1970).

* MCL = Maximum Contaminant Level
** TT = Treatment Technique

In February 1984, SFC[1] submitted all monitoring results and reports from the pilot injection test to the NRC. These reports indicated the deep injection well performed satisfactorily and that the Arbuckle Reservoir was capable of accepting the injected liquids. Also, at this time, the SFC requested permission from the OSDH and the NRC to inject an additional 132,500 liters (35 million gallons) of treated raffinate over a 14-month period. On July 10, 1984, the NRC's consultant indicated to the NRC that SFC had provided sufficient information, and recommended that the requested injection of 132,500 liters (35 million gallons) be approved. On August 31, 1984, the OSDH issued a draft permit for injection of this amount of treated raffinate. A final permit was not to be issued until public comment was obtained. In the fall of 1985, a public hearing was held, and the injection project was abandoned due to overwhelming public opposition.

In December 1985, the SFC decided to plug the deep injection well in response to the negative public opinion received during the public comment period, and the plugging process was overseen by representatives of the OSDH and Oklahoma Water Resources Board (OWRB). In December 1987, the OSDH granted the SFC approval to also plug and abandon the four monitoring wells associated with the deep injection well that were installed between 1970 and 1984. These ground-water monitoring wells were shortly plugged and abandoned by the SFC.

In September 1994, the SFC requested a review of the relevant documents by Roberts/Schornick & Associates (RSA). RSA concluded that the well casings were properly installed and had sufficient seals between the casing and borehole wall to prevent vertical migration of fluids behind the casing during the pilot test or from natural formation pressures (RSA, 1995). There was no significant boundary leakage, no vertical interconnection between layers forming the reservoir, and no significant horizontal heterogeneity within each layer. Injection of fluids could occur with little risk of fluid movement out of the Arbuckle Formation Reservoir. Injection of this fluid could not increase the Arbuckle Formation pressures sufficiently to bring natural brines into contact with fresh groundwater horizons.

G.3 Ammonium Nitrate Fertilizer Program

G.3.1 Introduction

Once the raffinate was neutralized and the impurities were precipitated, the resulting liquid, designated as SFC-N, was a dilute ammonium nitrate solution. In fact, chemical analysis of the SFC-N showed it to contain fewer impurities than commercial ammonium nitrate fertilizers (SFC, 1994). The SFC-N was stored in open ponds on the site and sprayed as nitrogen fertilizer principally between 1973 and 1994 on farmland used to grow forage crops for livestock. Periodic application of this fertilizer onto the agricultural lands in the south portion of the SFC site has occurred since 1994 as given in annual reports with the latest one for the year 2001 (SFC, 2002). Figures G-1 and G-2 identify the land areas treated with SFC-N fertilizer between 1973 and 1994.

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[1] In October 1983, KMNC divided its assets and became two new subsidiary companies with the SFC the designated owner of the uranium conversion facility at Gore, Oklahoma.

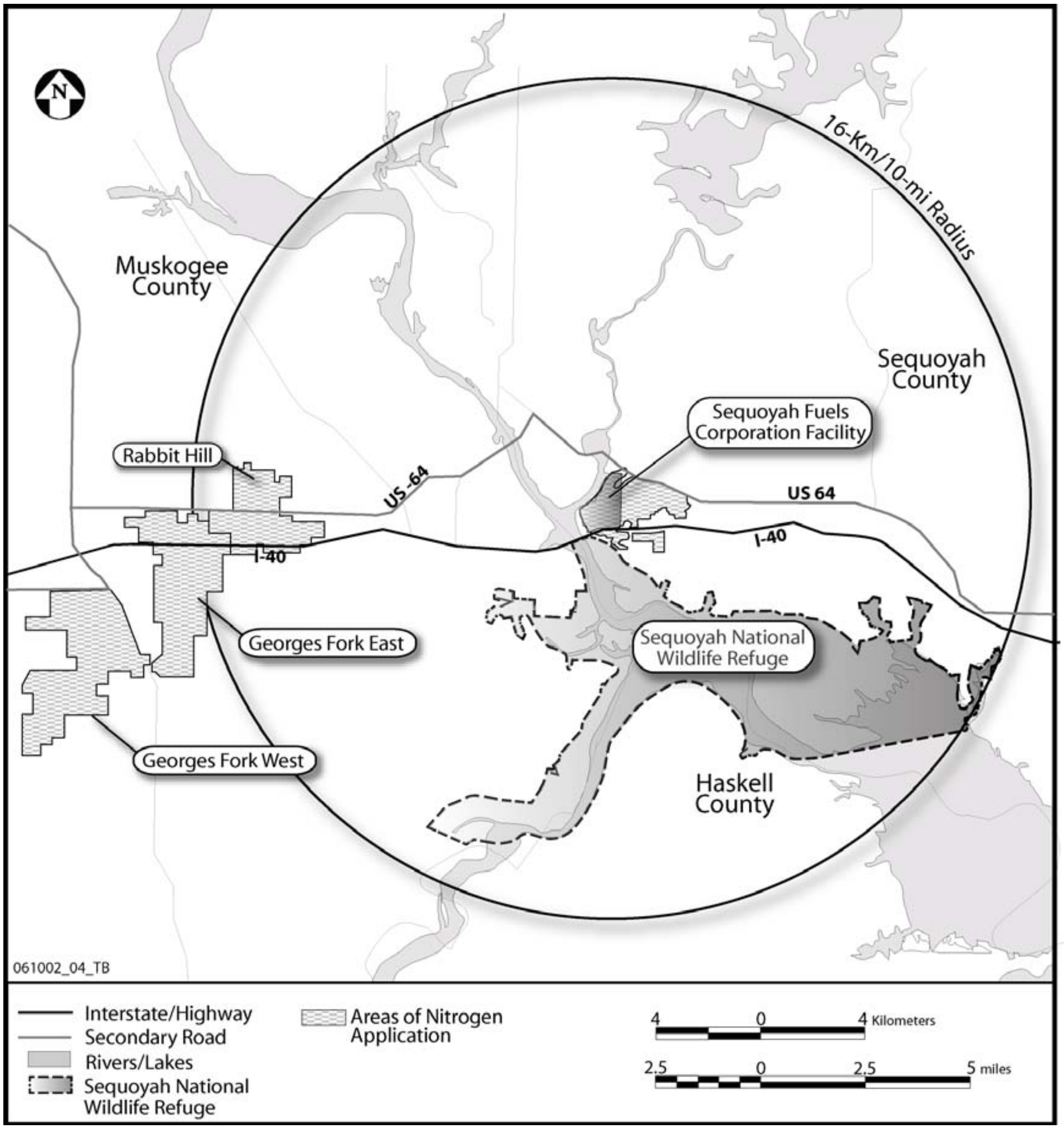

Figure G-1 Properties Treated with SFC-N Fertilizer Between 1973 and 1994

The NRC, Oklahoma State University, and the EPA monitored the program and reviewed the results of chemical and radiological analyses of the fertilizer, soil, groundwater, surface water, forage crops, and grazing livestock. While a few of the individual test reports showed unusually high concentrations of certain heavy metals, re-sampling of the same area did not reproduce similar concentration levels. The high readings were considered sampling error or sample contamination (OSDH, 1985). The vast majority of the studies reflect no adverse impact from the SFC-N.

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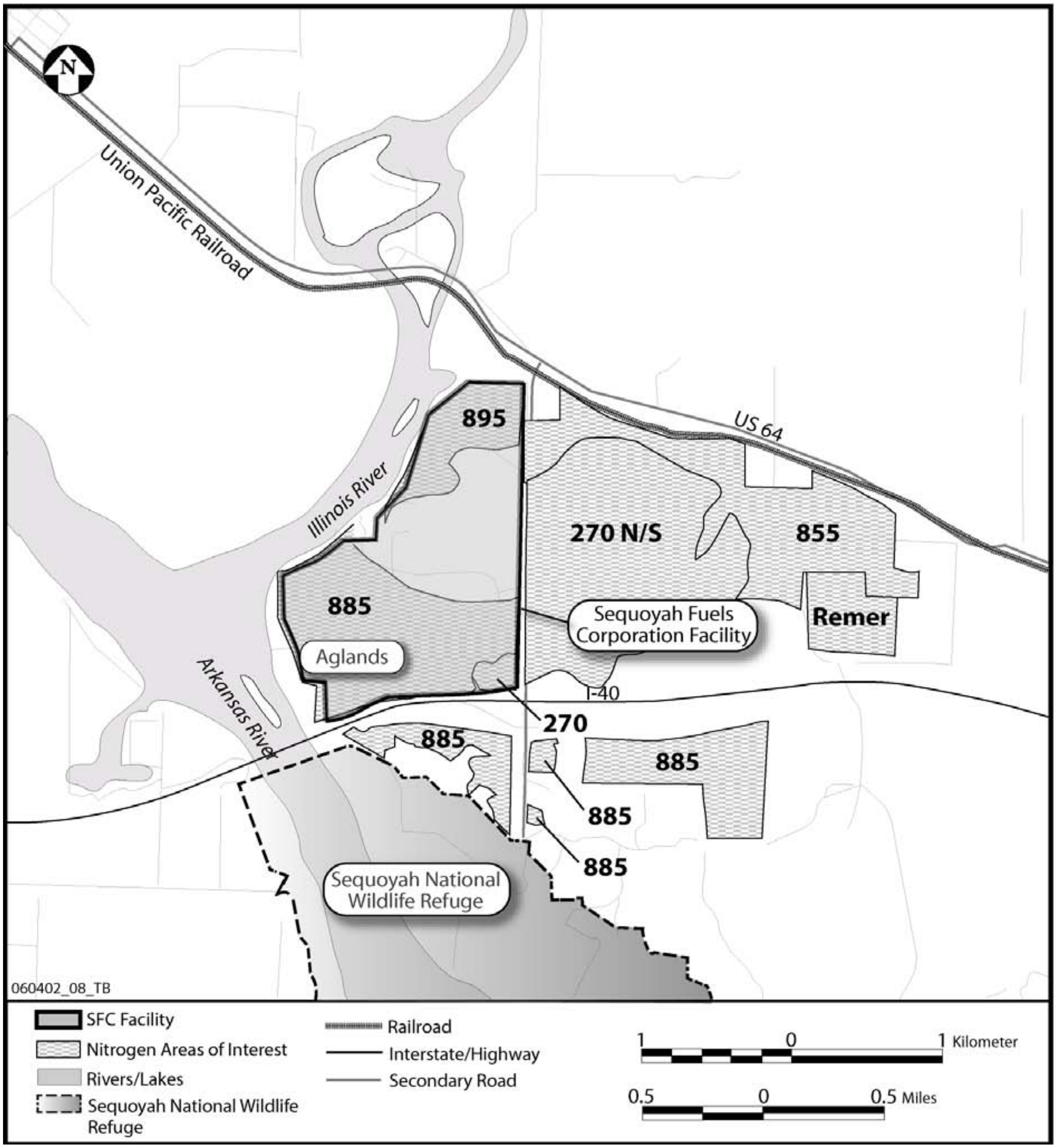

Figure G-2 Properties Treated with SFC-N Fertilizer Between 1973 and 1994

contamination (OSDH, 1985). The vast majority of the studies reflect no adverse impact from the SFC-N.

G.3.2 Initial Test Plots

The fertilizer spray program began in 1973 after the licensee (KMNC until 1987) showed that the waste nitric acid solution could be neutralized with anhydrous ammonia and treated with barium nitrate to precipitate almost all of the trace metals and contaminates (Tucker et al., 1988).

The resultant liquid was a 2- to 5-percent ammonium nitrate solution similar to commercially available nitrate fertilizer.

In 1972, the licensee (until 1987, Kerr-McGee Corporation) applied to the AEC to test the viability of using SFC-N as fertilizer. The AEC granted permission in 1973, and testing began with a 400 feet by 400 feet (122 m by 122 m) plot. Table G-2 contains the chemical analyses of the SFC-N as first applied, and mean chemical analysis of soil and vegetation from the 1973 experiment. The original application of SFC-N contained trace amounts of uranium (0.64 to 0.86 µg/g) and radium (0.29 to 2.9 pCi/L). Multiple samples of runoff water, soil, and vegetation were taken before, during, and after the application of SFC-N and compared to similar samples from an untreated area. Analysis of these samples showed very low levels of nitrate in the runoff water (a maximum of 5.6 mg/L) and very low levels of other contaminates in the soil and vegetation.

Table G-2 Analyses of Applied SFC-N Fertilizer, Soil, and Vegetation Preliminary Test (1973)

Analysis of SFC-N	NH4–N (µg/g)	NO3–N (µg/g)	Ca (µg/g)	F (µg/g)	Na (µg/g)	U (µg/g)	Ra (pCi/L)
8/8/73 to 9/4/73	1,800	6,600.00	7,000.00	13.00	1,150.00	0.64	2.900
9/21/73 to 11/6/73	1,860	6,700.00	7,000.00	9.00	--	0.86	0.290
Amt. applied (lbs./acre)*	280	1,017.00	1,071.00	0.14	176.00	0.01	--
Soil Analysis							
Control– 5/17/73	--	18.90	--	98.00	--	2.50	0.330
Control– 9/8/73	--	10.00	2,000.00	33.00	--	3.80	--
Control– 1/10/74	--	<10.00	2,000.00	39.00	--	1.80	<0.005
Test Plot– 5/17/73	--	11.00	--	79.00	--	0.80	0.100
Test Plot– 9/8/73	--	<10.00	890.00	31.00	--	0.80	--
Test Plot– 1/10/74	--	<10.00	1,290.00	47.00	--	1.20	0.010
Vegetation Analysis							
Control– 5/17/73	--	--	1,850.00	4.00	--	1.10	0.080
Control– 9/8/73	--	25.00	1,850.00	2.20	--	2.70	--
Control– 1/10/74	--	<10.00	1,820.00	17.00	--	0.40	0.005
Standard deviation	--	12.60	--	--	--	1.18	0.053
Test Plot– 5/17/73	--	--	--	2.00	--	0.60	0.200
Test Plot– 9/8/73	--	225.00	2,880.00	7.80	--	0.50	--
Test Plot– 1/10/74	--	<10.00	1,360.00	3.00	--	0.40	0.010
Standard deviation	--	152.00	--	--	--	0.10	0.134

* To convert lbs./acre to kg/hectare multiply lbs./acre by 1.12.
Source: Tucker et al., 1988.

Because of the success of the 1973 test plots, the NRC approved Kerr-McGee's request to expand the testing. From 1974 through 1976, four demonstration plots were established in the same area as the 1973 test. One plot was used as a control and received no treatment, two of the test plots received SFC-N, and one plot received an equivalent level of commercial nitrogen fertilizer. Runoff water from each plot was directed into separate catch basins for volume measurement and sampling. Periodic soil and vegetation analyses were performed and are reported in Table G-3.

Table G-3 Analysis of SFC-N and Commercial Ammonium Nitrate on Four Test Plots From 1974 to 1976

	Test Plot Number			
	1	**2**	**3**	**4**
Fertilizer Type	**SFC-N**	**SFC-N**	**Commercial**	**Control**
1974 Growing Season				
Nitrogen (N) in SFC-N (lbs. N/acre)*	1,080.0	519.0	--	--
N in Commercial Fertilizer (lbs. N/acre)*	--	--	466.0	--
Radium applied with N (pCi X 103)	49.3	34.8	104.9	--
Bermuda grass yield (lbs./acre)*	6,179.7	7,793.0	6,815.0	4,800.0
N uptake in Bermuda grass (lbs. N/acre)*	187.4	161.1	184.8	173.6
1975 Growing Season				
Nitrogen (N) in SFC-N (lbs. N/acre)*	980.0	516.0	--	--
N in Commercial Fertilizer (lbs. N/acre)*	--	--	517.0	--
Radium applied with N (pCi X 103)	3.1	9.1	9.2	--
Bermuda grass yield (lbs./acre)*	13,804.5	11,214.1	11,681.6	6,688.2
N uptake in Bermuda grass (lbs. N/acre)*	317.0	203.1	247.0	81.6
1976 Growing Season				
Nitrogen (N) in SFC-N (lbs. N/acre)*	906.0	531.0	--	--
N in Commercial Fertilizer (lbs. N/acre)*	--	--	524.0	--
Radium applied with N (pCi/L)	N/A	N/A	N/A	--
Bermuda grass yield (lbs./acre)*	9,086.0	6,066.1	6,936.0	2,529.3
N uptake in Bermuda grass (lbs. N/acre)*	269.4	188.2	215.5	43.8
Three-Year Average (1974 to 1976)				
Nitrogen (N) in SFC-N (lbs. N/acre)*	988.7	522.0	--	--
N in Commercial Fertilizer (lbs. N/acre)*	--	--	502.3	--
Radium applied with N (pCi/L)	26.2	22.0	57.1	--
Bermuda grass yield (lbs./acre)*	9,690.1	8,357.7	8,477.5	4,672.4
N uptake in Bermuda grass (lbs. N/acre)*	257.9	184.1	215.8	66.3

* To convert lbs./acre and lbs. N/acre to kg./hectare and kg. N/hectare, multiply lbs./acre by 1.12.
Source: Tucker et al., 1988.

The 1974 to 1976 studies showed that SFC-N was equivalent to commercial ammonium nitrate fertilizer in its effects on soil processes and plant growth (Tucker et al., 1988). Forage produced by fertilization with SFC-N was normal, and concentrations of radionuclides and trace elements were well within animal diet standards. As can be seen in Table G-3, equivalent amounts of nitrogen from commercial ammonium nitrate fertilizer and SFC-N produced almost twice as much bermuda grass as the untreated control plot. Additionally, the quantity of radium in the commercial fertilizer was more than twice that of the SFC-N. After review of this information, the NRC approved Kerr-McGee's request to expand its testing to a 160-acre plot south of the Sequoyah facility (Tucker et al., 1988).

G.3.3 160-Acre Test

Between 1977 and 1984, Kerr-McGee divided a 64.7-hectares (160-acre) section of Kerr-McGee land into six provinces according to the soil type and vegetation. This section of land and the fertilizer-spreading program was designated as the 160-acre test tract. Each province was segregated with runoff control dikes and perimeter diversion ditches to collect rain water. Shallow monitoring wells were installed, and a detailed soil analysis was performed to provide baseline data before the initial application of SFC-N.

In 1977, provinces 1 and 2 received nitrogen loadings equivalent to what a farmer would use on normal grazing land, while provinces 3, 4, 4a, and 5 received 2 to 3 times the normal nitrogen loading. Nitrogen monitoring of both ground water and runoff showed most samples below the 10 mg/L limit for human consumption. The few water samples that exceeded the 10 mg/L drinking water limit had values of 14 to 44 mg/L, which was still within acceptable limits for animal consumption. One sample showed 79 mg/L in 1979—this abnormally high reading may have been caused by accidental contamination of the monitoring well or sample.

Of course, good soil requires more than just nitrogen to produce good crops. Commercial phosphate, potash, and agricultural lime (aglime) were added as determined by soil analyses. These loadings constituted the total inputs for pasture management of the 160-acre test tract excluding mineral supplements and grain fed to grazing cattle, and material from rain, snow, and windstorms.

During 1978 and 1979, Kerr-McGee developed a cattle-testing program in conjunction with the Oklahoma State University Animal Disease Diagnostic Laboratory, the Oklahoma Department of Agriculture, and the NRC. The program was designed to compare the effects of SFC-N with commercial ammonium nitrate fertilizer on grazing animals and the human food chain. There was no significant difference in average weight gain between the two groups, and all of the heavy metal and radionuclides analyses were within expected normal background levels for both the experimental and control groups. A summary of these findings is shown in Table G-4.

Table G-4 Average Heavy Metal and Radionuclide Content of Blood and Selected Tissue From Cattle Grazing in Pastures Fertilized with SFC-N and Commercial Urea Nitrogen Sources (1978-1979)

Material		Blood	Kidney	Liver	Brain	Heart	Bone	Muscle
Pb (mg/L)	SFC-N	0.0340	0.2300	0.0650	--	--	--	0.2000
	Urea	0.0300	0.4100	0.5800	--	--	--	0.1100
Zn (mg/L)	SFC-N	2.3000	19.9000	33.9300	--	--	--	36.1000
	Urea	2.4000	18.2800	42.6500	--	--	--	45.7300

Table G-4 Average Heavy Metal and Radionuclide Content of Blood and Selected Tissue From Cattle Grazing in Pastures Fertilized with SFC-N and Commercial Urea Nitrogen Sources (1978-1979)

Material		Blood	Kidney	Liver	Brain	Heart	Bone	Muscle
Cu	SFC-N	1.0230	7.7250	20.8500	--	--	--	5.0750
(mg/L)	Urea	0.9900	6.3630	35.3500	--	--	--	3.6250
Cd	SFC-N	--	1.2500	0.2250	--	--	--	0.0600
(mg/L)	Urea	--	0.8750	0.2500	--	--	--	0.0800
Mo	SFC-N	0.0350	1.3550	1.8280	--	--	--	0.9050
(mg/L)	Urea	0.0480	5.0400	5.0400	--	--	--	3.8930
As	SFC-N	--	0.2000	0.0200	--	--	--	0.0200
(mg/L)	Urea	--	0.4000	0.0400	--	--	--	0.1000
Ni	SFC-N	--	0.1007	0.1035	--	--	--	0.1600
(mg/L)	Urea	--	0.1600	0.0650	--	--	--	0.1500
U	SFC-N	0.0013	0.0173	0.0015	0.0015	0.0020	0.0128	0.0025
(mg/L)	Urea	0.0072	0.0175	0.0035	0.0010	0.0027	0.0013	0.0010
Ra	SFC-N	--	0.0025	0.0018	0.0040	0.0015	0.0625	0.0008
(pCi/g)	Urea	--	0.0052	0.0015	0.0030	0.0020	0.0950	0.0015
Th	SFC-N	--	0.0040	0.0030	0.0007	0.0004	0.0011	0.0003
(pCi/g)	Urea	--	0.0030	0.0020	0.0006	0.0002	0.0013	0.0002

Source: Tucker et al., 1988.

The 160-acre experiment showed that SFC-N was an effective source of nitrogen for forage production, and it reacted like commercially available ammonium nitrate fertilizer. There was no statistical difference in cattle feed grass grown with SFC-N, and the use of SFC-N had no adverse affect on the soil, water, or cattle (Coleman, 1985).

G.3.4 270-Acre Test

In 1979, Kerr-McGee expanded the fertilizer program to include an additional 109 hectares (270 acres) of Kerr-McGee land adjacent to the Kerr-McGee facility designating this additional program as the 270-acre test tract. As with the 160-acre field test, the area was surrounded with a perimeter diversion ditch, and pre-application soil samples were taken to establish a baseline reference for various chemicals. The testing program continued for 8 years and included monitoring of water, soil, and vegetation for metals and radionuclides.

Like the 160-acre test, the 270-acre test involved a comprehensive forage production program using SFC-N as the nitrogen fertilizer source and commercially available phosphate, potash, and aglime. Eight years of application effects were reviewed and summarized. Effects of treatments on soil, surface and ground water, and forage were tested. Nitrogen application rates, even though higher than average for the area, allowed for maximum grazing and haying use of the land. Forage yields over the 8-year period were very good, and the test plot was successful in assessing environmental impacts of the program (Tucker et al., 1988).

The SFC-N proved to be an effective source of nitrogen for growing grass, reacting like other available nitrogen fertilizers. As shown in Table G-5, the forage produced was no different than that forage produced using other nitrogen fertilizers, and there was no adverse affect on soils or water (Tucker et al., 1988).

Table G-5 Average of 8 Years of Chemical and Radiological Analysis of 270-Acre Test Plot

	Element Concentrations					
Pasture	**Ra (pCi/g)**	**Th (pCi/g)**	**U (µg/g)**	**Cu (mg/g)**	**Mo (mg/g)**	**Ni (mg/g)**
Control (not treated)	0.0240	0.0180	0.0800	0.0037	0.0044	0.0062
Rye (treated with SFC-N)	0.0250	0.0140	0.1000	0.0036	0.0040	0.0067

Source: Coleman, 1985.

G.3.5 885-Acre Expansion Tract

Based on the results of the previous experiments, the NRC allowed another expansion of the testing program. In June 1980, Kerr-McGee added an additional 358 hectares (885 acres) to the SFC-N testing program designated as the 885-acre expansion tract. The 885-acre expansion tract includes shallow soils with limited production capability. The soils are underlain with clay subsoil that overlies layers of gravelly sandstone and shale. Most of the area was timbered. To facilitate application of the fertilizers, Kerr-McGee cut access roads 6.1 m (20 ft.) wide and 30.5 m (100 ft.) apart and seeded them with fescue. They divided the 358 hectares (885 acres) into 27 subplots and selected six of the subplots for intensive monitoring. Kerr-McGee chose the six selected areas because they represented the soil samples in the total area.

All of the 358 hectares (885 acres) received uniform quantities of SFC-N and commercial phosphate, potash, and aglime from 1980 through 1982. Thereafter, residual soil testing was used to determine application rates for all of the fertilizers. The area received SFC-N as nitrogen fertilizer for 7 years, from 1980 to 1987. Nitrogen content of the SFC-N varied from 2.18 to 5.0 percent, and the applied quantity of the SFC-N was adjusted to maintain a constant application rate in pounds of nitrogen per acre as determined by soil samples and nitrogen concentration.

The fertilizer program on the 885-acre tract continued to exhibit the results noted in previous areas. Fescue grew profusely in the cleared strips and invaded the uncleared areas. Kerr-McGee noted greatly improved production from the native grass in the timbered areas. Cattle grazing on this land was successful, and no problems were encountered (Tucker, 1995).

G.3.6 Rabbit Hill Field Monitoring

In 1982, the NRC authorized the continued use of SFC-N ammonium nitrate on the 160-, 270-, and 885-acre test tracts and allowed expansion of the program to another area—a 283 hectare (700-acre) company-owned tract known as Rabbit Hill near Warner, Oklahoma. Rabbit Hill's soil is primarily deep clay-pan prairie-type soil with some shallow and steep soils similar to the 885-acre tract. Vegetation on Rabbit Hill is mainly bermuda grass and fescue with some small timbered areas.

Analysis of the existing soil at Rabbit Hill showed it to be acidic and very low in phosphorus and potassium. Correcting these deficiencies required the application of large quantities of K_2O,

P_2O_5, and aglime along with the SFC-N. All of these materials were applied annually in accordance with recommendations from the Oklahoma State University and based on soil tests.

Table G-6 depicts the average loading rates of SFC-N, concentrated superphosphate, and sulfate of potash-magnesia fertilizers and aglime applied to Rabbit Hill between 1982 and 1986, along with a chemical analysis of each of the fertilizers. As Table G-6 shows, the percentage quantity of each trace element contributed by SFC-N is quite small compared to the amounts added from the other sources (Tucker, 1995). Detailed analyses of soil, vegetation, and ground water from the Rabbit Hill area showed nothing unusual, and all values were below the standards set for safe use of the material (Tucker, 1995).

Table G-6 Average Yearly Quantity and Analysis of Fertilizers Applied to Rabbit Hill From 1982 to 1986

Material	SFC-N	P_2O_5	K_2O	Aglime
SFC-N (Nitrogen)– lbs./acre*	304			
P_2O_5– (0-45-0)– lbs./acre*		43		
K_2O– (0-0-22-20)– lbs./acre*			42	
Aglime– lbs./acre*				2,364
Chemical Analysis	**SFC-N**	**P_2O_5**	**K_2O**	**Aglime**
As, median measured level in mg/L	0.95	33.50	42.80	18.00
B, median measured level in mg/L	0.87	40.10	35.75	25.60
Ba, median measured level in mg/L	0.40	20.58	6.80	29.50
Cd, median measured level in mg/L	0.11	17.05	9.08	10.65
Cu, median measured level in mg/L	5.42	32.60	13.00	3.50
Mo, median measured level in mg/L	11.63	13.00	3.05	7.50
N, median measured level in g/L	29.97			
Ni, median measured level in mg/L	10.62	24.00	19.58	5.50
Pb, median measured level in mg/L	0.30	14.10	21.01	41.30
U, median measured level in mg/L	0.02	76.55	0.37	0.69
Ra-226, median level	0.32 pCi/L	7,260 pCi/kg	342.5 pCi/kg	61.5 pCi/kg
Th-230, median level	0.26 pCi/L	4,750 pCi/kg	909 pCi/kg	190 pCi/kg

* To convert lbs/acre to kg/hectare, multiply the lbs/acre by 1.12.
Source: OSDH, 1985.

The Rabbit Hill farm is a commercial hay and livestock enterprise. The result of the fertilizer program at Rabbit Hill was that good hay yields were obtained, and grazing performance on the pastures was superb. Ground-water quality was very good, and no buildup of any trace elements or radionuclides was found in the soil or vegetation (Coleman, 1985).

G.3.7 Remer Tract

Kerr-McGee added a 30.4-hectare (75-acre) tract east of the 885-acre tract to the fertilization program in 1984. This property, known as the Remer tract, was included as part of the 885-acre tract for operations. Tract monitoring consisted of soil and forage analysis. Fertilizer application methods were similar to those previously described for other areas. Deficiencies in plant food elements were supplied in response to soil tests. The average quantity and quality of fertilizers and aglime applied to the Remer tract between 1984 and 1986 are shown in Table G-7.

Table G-7 Average Yearly Quantity and Analysis of Fertilizers Applied to Remer Property From 1984 to 1986

Material	SFC-N	P_2O_5	K_2O	Aglime
SFC-N (Nitrogen)– lbs./acre*	256.00			
P_2O_5– (0-45-0)– lbs./acre*		20.00		
K_2O– (0-0-22-20)– lbs./acre*			38.33	
Aglime– lbs./acre*				666.67
Chemical Analysis	**SFC-N**	**P_2O_5**	**K_2O**	**Aglime**
As, median measured level in mg/L	1.15	32.50	43.00	32.75
B, median measured level in mg/L	1.25	39.91	27.50	28.10
Ba, median measured level in mg/L	0.34	20.58	2.25	29.50
Cd, median measured level in mg/L	0.07	17.30	9.18	10.65
Cu, median measured level in mg/L	5.89	27.60	12.00	2.33
Mo, median measured level in mg/L	12.37	14.00	5.50	7.50
N, median measured level in g/L	27.53			
Ni, median measured level in mg/L	9.98	23.50	8.50	3.98
Pb, median measured level in mg/L	0.33	13.75	4.00	41.25
U, median measured level in mg/L	0.03	94.75	0.60	0.20
Ra-226, median level	0.378 pCi/L	13,490 pCi/kg	81.5 pCi/kg	56.5 pCi/kg
Th-230, median level	0.213 pCi/L	66,800 pCi/kg	80 pCi/kg	202 pCi/kg

* To convert lbs/acre to kg/hectare, multiply the lbs./acre by 1.12.
Source: OSDH, 1985.

All farming practices such as fertilizer and aglime application procedures and timing, hay harvesting, and cattle grazing management described earlier were followed on the Remer tract. Kerr-McGee collected and analyzed both pre-season and post-season soil samples for each of the three years. These analyses were used to determine fertilizer application recommendations and monitor for metal and radionuclide concentration. No buildup of any of the parameters was noted (Tucker, 1995).

Hay produced on the tract underwent comprehensive analytical testing. All concentrations of trace elements and radionuclides were low (i.e., many below detectable limits) and well within established limits for livestock feed. This tract has responded to the fertilizer program as predicted. Hay growth and yields have been good and equivalent to hay production from similar soils in eastern Oklahoma using similar forage management and fertilizer programs. No problems were encountered with hay quality or buildup of any deleterious substances (Tucker, 1995).

G.3.8 Georges Fork Ranch Field Monitoring

Kerr-McGee added the 3,100-hectare (7,660-acre) Georges Fork Ranch to its fertilizer application program in 1986. Georges Fork Ranch is southwest of the Rabbit Hill area, and Kerr-McGee owned and operated it as a commercial cattle production facility. Stocker cattle were grazed from fall until early summer, and excess summer forage was harvested for high-quality hay. Summer hay was fed to the cattle in the winter or sold.

As with the other acreage treated with SFC-N fertilizer, Kerr-McGee sampled the soil prior to treatment to determine background levels and recommended fertilizer applications. The Oklahoma State University Agronomic Services Laboratory provided recommended application guidelines for nitrogen, phosphorous, and potassium fertilizer and aglime. Five representative pastures in the 3,100 hectares (7,660 acres) were selected for intensive monitoring. One pasture was used as a "control" pasture and treated with commercial ammonium nitrate in lieu of the SFC-N ammonium nitrate fertilizer.

Extensive monitoring of ground water, surface water, soil, and forage from 1986 through 1993 showed increased forage production and no adverse impacts from the SFC-N fertilizer. Table G-8 shows the average annual application rate of fertilizers and aglime as well as the mean chemical analysis of the material applied to the Georges Fork Ranch between 1986 and 1993. Results of these analyses demonstrate findings similar to all of the earlier fertilizer assessments—SFC-N can be used in place of commercial ammonium nitrate fertilizer without adversely impacting the soil, water, vegetation, or grazing livestock (SFC, 1994).

Table G-8 Average Yearly Quantity and Analysis of Fertilizers Applied to Georges Fork From 1986 to 1993

Material	**SFC-N**	**P_2O_5**	**K_2O**	**Aglime**
SFC-N (Nitrogen)– lbs./acre*	345.5			
P_2O_5– (0-45-0)– lbs./acre*		60		
K_2O– (0-0-22-20)– lbs./acre*			80	
Aglime– lbs./acre*				3,000
Chemical Analysis	**SFC-N**	**P_2O_5**	**K_2O**	**Aglime**
As, median measured level in mg/L	0.83	550.00	0.60	5.50
B, median measured level in mg/L	1.65	1.20	21.00	1.20
Ba, median measured level in mg/L	0.26	46.50	1.20	1.00
Cd, median measured level in mg/L	0.05	4.40	0.30	1.00
Cu, median measured level in mg/L	6.53	4.65	5.80	1.00
Mo, median measured level in mg/L	8.30	10.50	5.00	1.00
N, median measured level in g/L	21.50			
Ni, median measured level in mg/L	14.00	11.50	11.00	3.50
Pb, median measured level in mg/L	0.15	12.50	0.01	2.50
U, median measured level in mg/L	0.01	71.00	0.64	0.31
Ra-226, median level	0.345 pCi/L	12,750 pCi/kg	680 pCi/kg	0.08 pCi/kg
Th-230, median level	0.036 pCi/L	82,000 pCi/kg	140 pCi/kg	0.16 pCi/kg

* To convert lbs/acre to kg/hectare, multiply the lbs/acre by 1.12.
Source: OSDH, 1985.

G.3.9 EPA Review

In 1995, the EPA reviewed SFC test data and performed independent confirmatory sampling of the soil, ground water, surface water, and forage in the areas treated with SFC-N (PRC, 1997).

The 1995 EPA sampling data indicated that the application of SFC-N fertilizer did not affect the soil, ground water, or surface water within the fertilizer application areas or surrounding offsite farmland.

It was assumed that, if the SFC-N fertilizer had affected the soil, various metal concentrations would be elevated in most, if not all, of the soil samples. However, all of the observed metal concentrations were either within or only slightly above the RCRA Facility Investigation upper prediction intervals (SFC, 1996). The data indicate that the presence of these metals in a few area samples was not caused by the application of SFC-N fertilizer, but rather was the result of naturally occurring metal constituents in the soil (PRC, 1997).

Most of the ground-water samples from monitoring wells showed nitrogen levels well below the 10 mg/L limit for human consumption. However, two monitoring wells (MR-1 and MR-4) at Georges Fork Ranch have continually reported concentrations of nitrate above the 10 mg/L limit. One well, MR-1, is in the control plot for Georges Fork Ranch and has never received SFC-N fertilizer. The source of the high-nitrate concentration in these wells was never clearly established.

Surface-water samples were collected from ponds on the 270-Acre tract, Rabbit Hill, and Georges Fork Ranch and analyzed for hazardous metals and nitrate. None of the samples contained concentrations above livestock standards (PRC, 1997).

Increased crop yields demonstrate the viability of SFC-N as a nitrogen fertilizer. However, the data also indicate that SFC-N contains trace element impurities, particularly copper, nickel, and molybdenum. Trace element concentrations in forage produced using SFC-N fertilizer were compared to livestock dietary standards. The comparison indicates that molybdenum was the most critical of the three trace elements because its concentration in the SFC-N was about equal to the dietary standard. Therefore, molybdenum might accumulate in the forage at concentrations that exceed recommended dietary standards. The EPA recommends a maximum soil concentration of 5 mg/L for molybdenum, which is estimated to limit plant concentration to less than 10 mg/L.

Forage analyses from 1993 showed several pastures with molybdenum levels above the acceptable 10 mg/L. The highest concentration of 24.0 mg/L was found in the Agland application area on the west side of the SFC site. However, when these pastures were re-sampled in 1995, the results did not confirm the high concentrations of molybdenum. A review of the data indicates that molybdenum could be a problem but no conclusive evidence could be found to demonstrate a buildup of molybdenum in the soil or forage crops (Tucker, 1995).

G.3.10 Summary of Fertilizer Program

Since 1973, the SFC produced ammonium nitrate solution from waste nitric acid used in the uranium purification process. The nitric acid was treated with anhydrous ammonia and barium nitrate to raise its pH and precipitate out trace element impurities. The result was SFC-N that was applied, as nitrogen fertilizer, to lands used to produce forage crops.

While the NRC never licensed the spreading of the SFC-N, nor did they have any regulatory interest in the land used for the fertilizer program (Hickey, 1998), the NRC, Oklahoma State

University, and the EPA monitored the program and reviewed the results of chemical and radiological analyses of the fertilizer, soil, ground water, surface water, forage crops, and grazing livestock. While a few of the individual test reports showed unusually high concentrations of certain heavy metals, re-sampling of the same area did not reproduce similar concentration levels, and the high readings were considered a sampling error or sample contamination. The vast majority of the studies show no adverse impact from the SFC-N. In fact, chemical analysis of the SFC-N showed it to contain fewer impurities than commercial ammonium nitrate.

The overall conclusion of the studies and reports found no adverse environmental impact from the use of SFC-N when compared to commercial ammonium nitrate fertilizer. Chemical and radiological analysis of soils, waters, plants, and animals from the treated areas showed material levels that were statistically identical to similar samples from untreated areas (OSDH, 1985).

G.3.11 References

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APPENDIX H

PUBLIC COMMENTS ON THE

DRAFT ENVIRONMENTAL IMPACT STATEMENT

H.1 Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff published a notice in the Federal Register (72 FR 54080, September 21, 2007) requesting public review and comment on the Draft Environmental Impact Statement (DEIS) for the Reclamation of the Sequoyah Fuels Corporation Site, in accordance with Title 10, Part 51 of the U.S. Code of Federal Regulations (CFR). The official public comment period began with publication of the U.S. Environmental Protection Agency's (EPA's) Notice of Availability on September 21, 2007. The NRC staff established November 5, 2007, as the deadline for submitting public comments on the DEIS, consistent with the cited NRC regulations. The NRC staff conducted a public meeting in Gore, Oklahoma, on October 16, 2007. Oral comments were received from four individuals at the public meeting. Following the public meeting, the NRC received comment letters from five federal and state organizations and one private citizen.

Public Participation in NRC's Environmental Review Process

Public participation is an essential part of the environmental review process. The NRC conducted an open, public EIS development process consistent with the requirements of the National Environmental Policy Act of 1969 (NEPA) and the NRC's regulations (10 CFR Parts 51.73, 51.74, and 51.117). Following NRC's reclassification of waste at the SFC facility (see Section 1.3.1), the NRC published a Federal Register notice (68 FR 20033, April 23, 2003) for a rescoping meeting. The NRC staff conducted the rescoping meeting on May 13, 2003, and a public meeting on the DEIS on October 16, 2007, during the public comment period. During the development of the DEIS, NRC sought input from a number of sources, including cooperating agencies and other state government agencies. The NRC provided a 45-day public comment period (September 21, 2007, to November 5, 2007) for agencies and the public to review the DEIS and provide comments. This EIS considered and addressed the 58 individual comments the NRC staff identified from letters and from oral comments given by four individuals. After receipt and consideration of public comments on the DEIS, the NRC staff prepared a Final EIS (FEIS) in accordance with 10 CFR Parts 51.90 and 51.91.

Public Scoping

The NRC's public scoping process for the EIS began on October 20, 1995, with the publication in the Federal Register (60 FR 54260) of a Notice of Intent to prepare an EIS for the proposed decommissioning of the SFC facility. Following reclassification of the waste at the SFC site by the NRC, a Notice of Intent to Conduct a Public Rescoping Meeting was published in the Federal Register on April 23, 2003 (68 FR 20033). The public rescoping meeting was held on May 13, 2003 in Gore, Oklahoma. At this meeting, the NRC staff provided a description of NRC's role, responsibilities, and mission; gave a brief overview of its environmental and safety review processes; discussed how the public could effectively participate in the environmental review process; and solicited input from the general public on environmental concerns related to the proposed reclamation.

Issuance and Availability of the DEIS

On September 21, 2007, in accordance with NRC regulations pursuant to the implementation of NEPA, the NRC staff published a Notice of Availability for the DEIS in the Federal Register (72 FR 54080). In the notice, the NRC staff provided information on how to obtain a free copy of the DEIS. In addition, copies of the DEIS were mailed to federal, tribal, state, and local government officials. An electronic version of the document and supporting information was made accessible through the NRC's project-specific Web site (accessible at http://www.nrc.gov/info-finder/decommissioning/uranium/sequoyah-env-review.html) and through the NRC's Agencywide Documents Access and Management System (ADAMS) database on the NRC's Web site.

Public Comment Meeting

On October 16, 2007, in Gore, Oklahoma, the NRC staff conducted a public meeting to receive oral comments on the DEIS from members of the public. The NRC staff selected the city of Gore as the location for the meeting because it is a few miles from the SFC site. Notice of the public meeting was published in the Federal Register and announcement flyers were sent to the local library.

Four people provided oral comments during the meeting. A certified court reporter recorded the oral comments and prepared a written transcript. The transcript is part of the public record for the proposed project and can be found on the NRC's project-specific Web site and in the administrative record in ADAMS (ML1072980315).

Comments Received on the DEIS

As discussed above, the NRC staff received both oral and written comments on the DEIS during the comment period. The NRC staff identified 58 substantive comments in the five letters received and from the oral comments.

Comment Review

The NRC staff reviewed each comment letter and the transcript of the public meeting. Table H-1 presents the comments, or summaries of comments, along with the NRC staff's corresponding responses. When comments resulted in a modification to the EIS, it is noted in the staff's response. In all cases, the NRC staff sought to respond to all comments received during the public comment period.

Major Issues and Topics of Concern

The majority of the comments received specifically addressed the scope of the environmental reviews, analysis, and issues contained in the DEIS, including existing conditions, potential impacts, proposed mitigation, and the NRC's environmental review process. However, other comments addressed topics and issues that were not part of the review process for the proposed action. Those comments included questions about the NRC's safety evaluation of the proposed disposal cell, security concerns, and observations regarding past SFC activities.

Comments on Out-of-Scope Topics

Some commenters raised issues that were not related to the NRC staff's environmental review of SFC's Reclamation Plan. However, a response to each comment is included in Table H-1.

NRC Safety Review Process

The NRC staff evaluates a proposed license amendment to determine whether an applicant has demonstrated compliance with the regulatory requirements pertaining to the proposed action. In the case of the license amendment submitted by SFC for the reclamation of their Gore, Oklahoma, site, the NRC staff evaluated the proposed action against the NRC's regulations found in 10 CFR Part 40, Appendix A. The NRC staff's evaluation of a licensee's demonstration of compliance with the regulations is documented in a Safety Evaluation Report. Requests by the NRC staff for additional information from the applicant are made publicly available. However, there is no requirement for a formal public comment resolution process for Safety Evaluation Reports.

Commenter and Comment Identification

The NRC staff received 58 comments from five organizations and four individuals. The commenters were given a letter designation and each comment was numbered sequentially. All comments and comment responses are provided in Table H-1.

The transcript of the public meeting and each letter received from the organizations and individuals have been filed in the NRC's Agencywide Documents Access and Management System (ADAMS), which is accessible to the public via the internet (nrc.gov). The locator number (ML number) in ADAMS is provided in Table H-1.

Table H-1 PUBLIC COMMENTS ON THE DEIS AND NRC STAFF RESPONSES

Letter/ Comment No.	Comment	Comment Response
U.S. Environmental Protection Agency (Letter dated 11/05/07; ADAMS ML073190070)		
EPA-1	In the area of air quality, we suggest that any demolition, construction, rehabilitation, repair, dredging or filling activities having the potential to emit air pollutants, be mitigated with the use of best management practices.	Air emissions generated during implementation of the reclamation activities proposed by SFC would be controlled through the application of best management practices. The EIS has been revised to include best management practices in Chapter 5.
EPA-2	EPA rates the DEIS as "LO," i.e., EPA has "Lack of Objections" to the proposed Federal action. Our classification will be published in the *Federal Register* according to our responsibility under Section 309 of the Clean Air Act to inform the public of our views on this proposed Federal action.	The NRC acknowledges your comment.
U.S. Department of Commerce (National Geodetic Survey) (Letter dated 10/25/07; ADAMS ML073090568)		
NGS-1	If there are any planned activities which will disturb or destroy geodetic control monuments, NGS requires notification not less than 90 days in advance of such activities in order to plan for their relocation. NGS recommends that funding for this project includes the cost of any required relocation(s).	The areas that would be disturbed by the proposed action or any of the reasonable alternatives do not include geodetic control monuments. The geodetic control monument location information was obtained through a web link provided to NRC by the US Department of Commerce (http://www.ngs.noaa.gov/). A figure showing the geodetic control monument locations relative to the SFC site has been added to the EIS as Figure B.3-4.
U.S. Department of Interior (Letter dated 11/01/07; ADAMS ML073090597)		
DOI-1	Since the radioactive elements in the sludge - 226radium, 230thorium, and 238uranium - have considerably long half-lives (1,600 years, 75,000 years, and 4.4 billion years, respectively), there is no guarantee that the proposed containment cell will be sufficient in retaining the raffinate sludge over the long term.	The proposed reclamation, including construction and maintenance of the disposal cell at the SFC site, are being evaluated by the NRC with respect to conformance with the criteria for decontamination, decommissioning, and reclamation specified in Appendix A to 10 CFR Part 40. This evaluation is documented in the NRC's Safety Evaluation Report (SER). The Appendix A criteria were established to provide reasonable assurance of control of radiological hazards for 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years. This requirement conforms to the standard established by EPA in 40 CFR Part 192. The Uranium Mill Tailings Radiation Control Act (UMTRCA) required EPA to establish standards for reclamation of 11e.(2) byproduct material and NRC to conform its regulations to the EPA standards. For performance beyond 1,000 years, the low-profile of the cell is designed such that any future releases of uranium-238, thorium-230, or radium-226 would be incrementally slow (erosion of a low-relief feature over geologic time), hence minimizing risks to the public health, safety, or the environment. For the period of future institutional control, the leak detection system and point of compliance wells required by the Appendix A criteria, and included in SFC's proposed disposal cell design, would provide for the earliest practical warning of any future release of hazardous constituents from the cell.

Table H-1 PUBLIC COMMENTS ON THE DEIS AND NRC STAFF RESPONSES

Letter/ Comment No.	Comment	Comment Response
		Such a release could be expected to be gradual, providing ample time to implement any mitigation measures necessary to control the release. The information regarding Appendix A criteria has been added to Chapter 1 of the EIS. The leak detection information has been added to Chapter 2 of the EIS.
DOI-2	The site is located adjacent to the Illinois River and the Arkansas River (McClelland-Kerr Arkansas River Navigation System) and is immediately upstream of the Sequoyah National Wildlife Refuge, so any unforeseen circumstances that might result in a leak from the containment cell may cause immediate contamination of the rivers and the Refuge. 226Radium in particular is highly 'radioactive, and because its chemical properties resemble those of calcium, exposure to or ingestion of radium poses severe toxicological risks due to substitution of radium for calcium in bones of vertebrates (1,2). Thus, any releases of 226radium into the Illinois or Arkansas Rivers can result in considerable health problems in fish, piscivorous or wading birds, and other vertebrates downstream of the site.	The proposed reclamation, including construction and maintenance of the disposal cell at the SFC site, are being evaluated by the NRC with respect to conformance with the criteria for decontamination, decommissioning, and reclamation specified in Appendix A to 10 CFR Part 40. This evaluation is documented in the NRC's SER. The Appendix A criteria were established to provide reasonable assurance of control of radiological hazards for 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years. This requirement conforms to the standard established by EPA in 40 CFR Part 192. The Uranium Mill Tailings Radiation Control Act (UMTRCA) required EPA to establish standards for reclamation of 11 e (2) byproduct material and NRC to conform its regulations to the EPA standards. For performance beyond 1,000 years, the low-profile of the cell is designed such that any future releases of uranium-238, thorium-230, or radium-226 would be incrementally slow (erosion of a low-relief feature over geologic time), hence minimizing risks to the public health, safety, or the environment. For the period of future institutional control, the leak detection system and point of compliance wells required by the Appendix A criteria, and included in SFC's proposed disposal cell design, would provide for the earliest practical warning of any future release of hazardous constituents from the cell. Such a release could be expected to be gradual, providing ample time to implement any mitigation measures necessary to control the release. Regarding any eventual releases of uranium, the total groundwater flux from the SFC site into the Kerr Reservoir averages 7,680 ft^3/day, whereas the flow down the Illinois River varies between 8,035,000 ft^3/day (low flow) and 133,480,00 ft^3/day (average flow). To exceed the uranium drinking water standard of 30 µg/L in the Illinois River, all of the groundwater crossing the site would have to have uranium concentrations of greater than 31,200 µg/L. Modeling of groundwater contamination at the SFC site indicates that the maximum uranium concentration in groundwater at the site boundary could reach approximately 135 µg/L. The effects of groundwater input would result in uranium concentrations increasing in the Illinois River by 1.3 µg/L. Radium-226 is less mobile than uranium and is present in lower concentrations than uranium at the SFC site. Under the current uncontained conditions at the site, the groundwater entering the river has not resulted in contaminant

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		increases in the river exceeding drinking water standards. Under present site conditions, the radium-226 concentrations in both groundwater and surface water remain below the drinking water standard of 5 pCi/L. Placing the contaminated soils and other materials in an engineered disposal cell would further isolate contaminants from the environment. The information regarding Appendix A criteria, the leak detection information, and the groundwater flux and river flow rates has been added to the EIS in Chapters 1,2, and 3, respectively. NRC's role in the EIS process has been clarified in Chapter 1.
DOI-3	The specifications of the containment cell, as set forth in the preferred alternative in the DEIS, appear to be formidable in safe-guarding against leakage, but long-term monitoring of the site and the containment cell extends only for 13 years. This seems like a very short period of time, considering that SFC began operations at this site more than 30 years ago. Unless there is a scientifically sound reason for limiting the monitoring to 13 years, the monitoring should be extended at least to a period equal to the term of the site's operation.	The reference to 13 years is the time estimated for groundwater treatment and recovery, not for long term groundwater monitoring. Groundwater treatment and recovery is required until the contaminant levels stipulated in an NRC-approved groundwater *Corrective Action Plan* are attained. Groundwater monitoring by the long-term custodian would continue indefinitely under the Long-Term Surveillance Program. This information has been clarified in Section 3.3.2 of the EIS.
DOI-4	We strongly suggest that at the very least, Alternative 3 (Partial Off-Site Disposal of Contaminated Materials) be employed instead of Alternative 1.	The role of the NRC as a regulator is to assess the licensee's proposed action with respect to public health and safety and the environment. Under NEPA, the EIS must consider reasonable alternatives to the licensee's proposed action to define the issues and provide a clear basis for choice among options by the decision maker and the public (40 CFR Part 1502.14). The EIS reviews and evaluates the impacts of the licensee's proposed action and two alternatives. However, as a regulator the NRC does not choose a preferred alternative in the EIS. NRC's role in the EIS process has been clarified in Chapter 1.
DOI-5	In addition, the habitat surrounding the SFC Site is known to contain American burying beetles *(Nicrophorus americanus)*, and it is possible that the grassy and wooded portions of the SFC Site will be used by the ABB. According to the DEIS, no site preparation or cell construction work will take place outside of the Industrial Area, but 2 acres of open-field habitat will be removed as part of the cell construction. The DEIS states that according to the FWS's 2005 Programmatic Biological Opinion (PBO) relating to oil and gas construction activities and their effects on ABB's in eastern Oklahoma, there will not likely be any adverse effects on ABB's by construction activities at the Site. The PBO was written specifically for the Environmental Protection Agency regarding oil and gas activities that required a storm water construction permit; the FWS concurred with EPA's determination that Adverse Impacts to the ABB	The open field habitat referred to in Appendix B, Section B.5.2.1, is the open field in the vicinity of the North Ditch and Emergency Basin, an area that is entirely within the heavily disturbed industrial area. Under Alternatives 1 and 3, the undisturbed area that could potentially harbor the ABB would be the clay borrow area in the southern part of the SFC site. This area may be used to obtain clay for the proposed disposal cell. NRC has engaged in Section 7 consultations with U.S. Fish and Wildlife Service (USFWS), to determine if any surveys, recovery activities, or other measures need to be taken at the SFC site to avoid adversely affecting the ABB. As a result of this consultation, the USFWS has recommended that a survey for the American burying beetle be conducted at the clay borrow area prior to initiating any reclamation activities. SFC has agreed to conduct this survey. The NRC has prepared a proposed mitigation plan (see Chapter 5), which is designed to minimize potential ad-

Table H-1 PUBLIC COMMENTS ON THE DEIS AND NRC STAFF RESPONSES

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	were likely, hence formal consultation was necessary. Furthermore, the oil and gas companies agreed in all their project designs proactively to implement conservation and minimization actions for the ABB. Therefore, the PBO and any recommendations or determinations contained within are not applicable as part of the DEIS. In addition, the Energy Policy Act of 2005 voided the PBO; therefore, SFC should engage in a Section 7 consultation with the Tulsa, Oklahoma, FWS Ecological Services Field Office to ensure that any proposed work will not adversely affect the ABB.	verse effects on the endangered American burying beetle, enhance upland woodland habitat, and preserve the hydrologic gradient of the proposed clay borrow area. If the American burying beetle is determined to be present, SFC will follow standard mitigation practices under USFWS Conservation Approach 1 (e.g., bait away and trap and relocation protocols) prior to implementation of reclamation activities in this area. If Alternative 2 were implemented, the NRC staff would re-engage the Section 7 consultation with USFWS to determine if the construction of the railroad spur might adversely affect the American burying beetle. The same process from survey to development and implementation of a USFWS-approved mitigation plan (if the ABB was identified) would be followed for the area being traversed by the railroad spur. This information would be required in the license amendment to NRC. This information has been added throughout pertinent sections of the EIS.
DOI-6	Section 3.3.1.1, Surface Water Quality, page 3-8, lines 34-36, and Table 3.3-1 Surface Water Summary, pages 3-10 to 3-11: Additional information is needed to enable the public to appropriately understand and evaluate the summary data presented in the table, including but not limited to the number of observations per parameter for each sampling reach or site, how the summary data were calculated when a range of values are not presented, and discharge values during sampling for critical paired data sets.	Table 3.3-1 has been revised to include additional surface water data including more specific information on the number of samples, and sampling dates. A table has been added (Table 3.3-2) to show the results and flow rates for the upstream and downstream river samples.
DOI-7	Figure 3.3-3, Location of Carlile School Fault Relative to the SFC site, page 3-15: The figure would be improved by adding an explanation of what the various shading patterns represent, providing a map scale, and showing cultural features to orient the reader.	The shading near the fault zone has been defined and a map scale has been added.
Oklahoma Department of Wildlife Conservation (Letter dated 10/24/07; ADAMS ML073110183)		
DWC-1	The SFC plan of a disposal cell to last 200 to 1000 years is inadequate when considering that the half-life of uranium contained within is 4 ½ billion years.	Please see response to comment DOI-1.
DWC-2	Simply fencing the site to provide security is inadequate considering the hazard potential of the site. Given the long-term nature of the environmental and human-health risks posed by the site, additional security measures are warranted. In addition, the adjacent 276 acres, designated for unrestricted use, could be used as outdoor recreational areas (i.e., hunting and fishing), placing the public at risk if the containment site is not properly secured.	Both physical and administrative security controls would be established at the SFC site. The proposed physical controls would include the disposal cell contour and a multi-layered cover system with a thickness of 3 meters (10 feet). A fence would be placed around the institutional control boundary (ICB) and custodial care would be implemented that would minimize the potential for recreational or other types of site trespass once the site is transferred to the United States Government or the State of Oklahoma. Surface reclamation and decontamination actions would occur across the entire site, including the area proposed for unrestricted release and within the ICB. The required soil cleanup levels were derived using a hypothetical resident

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		farmer scenario within the ICB, which assumed that a farmer would reside on the land within the ICB, and were based on ensuring that doses and risks to the farmer did not exceed the regulatory limits. Consequently, the residual radioactive contamination levels in surface soil would be less than or equal to those required by the NRC for unrestricted site access. NRC's draft SER (Section 6.2.2) indicates that the radiation exposure to an individual standing next to the disposal cell would be at background radiation levels because the materials to be placed in the cell do not emit highly penetrating radiation and the shielding provided by the proposed cell cover is expected to be very effective. Regarding radon emissions from the disposal cell, in the SER the NRC modeled the worst-case radon flux rate and compared the results with the 10 CFR Part 40, Appendix A, criterion of 20 picocuries (pCi) per square meter per second. The NRC calculations resulted in a value of 5.9 pCi per square meter per second which is less than the specified criterion. Therefore, if the security controls failed in the future and recreational uses occurred, there would be no unacceptable risk to the public. The radiation dose and risk assessment for implementation of all alternatives are provided in Section 4.4 and Appendix D of this EIS. The text in the EIS has not been changed.
DWC-3	Letters dated November 28 and November 30, 2006 from the Nuclear Regulatory Commission to the USFWS and the Director of ODWC stating that endangered or threatened species are not present at SFC location are in error. Sequoyah County is within the range of the American Burying Beetle and the DEIS has no plan of action if the beetle is discovered living on the plant location. SFC should develop a plan of action, should threatened or endangered species be discovered, and present this plan for agency comment prior to initiation of the remediation plan.	The NRC was aware that the ABB was potentially present in Sequoyah County and possibly occurred in the vicinity of the SFC site. Since the majority of the SFC site had already been significantly disturbed during the construction of the SFC facility and its subsequent industrial operations, NRC determined that the habitat in the proposed project area would not be suitable for the ABB and sent a letter to FWS in November 2006 requesting concurrence on this determina-tion. Based on this comment, however, SFC entered into informal Section 7 consultation with USFWS regarding the clay borrow area in the southern por-tion of the site. Please see response to comment DOI-5.
DWC-4	The disposal cell is designed with a liner that monitors groundwater leakage. If the liner malfunctions at any time, leachate from the cell could easily reach the Illinois and Arkansas Rivers. The lower Illinois River is well known as an excellent trout, striped bass, walleye, and sauger fishery. It is a unique fishery for the state of Oklahoma and provides thousands of hours of angling opportunities. The designated trout stream portion is one of two year round trout fisheries in the state. Anglers utilizing these fisheries pay for the majority of the state's trout stocking program through purchases of trout licenses. Contamination of the lower Illinois River trout stream not only would result in the loss of one premier	Please see response to comment DOI-2.

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Letter/ Comment No.	Comment	Comment Response
	trout fishery, but loss of revenue from this area would jeopardize the future of other trout fishing areas resulting in negative impact on local economies. The Arkansas River is noted for its blue catfish and flathead catfish fisheries. The integrity of the Sequoyah National Wildlife Refuge, established as mitigation for habitat loss construction of the McClellan-Kerr Navigation System, lies downstream from the proposed storage site would be compromised if materials stored at the site are not contained.	
DWC-5	The lower Illinois River trout stocking information on the DEIS page 3-7 is inaccurate. The river is stocked weekly throughout the year not every weekend from the end of March until July 4th and then every other week as described in the DEIS.	The source of information identified in the DEIS was the Lake Tenkiller web site (http://www.laketenkiller.com/illinois_river.asp). The text of the EIS has been corrected to reflect the information provided by the comment.
DWC-6	The potential for a breach in containment of materials in the storage facility jeopardizes the millions of dollars outdoor recreational activities provide to the economy of eastern Oklahoma and more specifically to the region where the Sequoyah Fuels facility is located. ODWC recommends Selecting Alternative 2 which involves shipping contaminated soil, buildings and other materials to a site currently approved for storage of hazardous materials. As the government agency charged with ensuring that Oklahoma's fish and wildlife resources are preserved for future generations, ODWC strongly urges NRC to require all hazardous materials and associated equipment be removed from the facility and grounds and disposed of in an area and manner that will best protect the public and the environment from possible exposure indefinitely.	Please see response to comments DOI-2 and DOI-4.
Oklahoma Office of Attorney General (Letter dated 11/05/07; ADAMS ML 073250213)		
OAG-1	Alternative 1 provides that all materials will be disposed on-site within a disposal cell. The State strenuously objects to this Alternative and requests that NRC takes all action necessary to effectuate the terms of the Settlement Agreement reached between SFC, the State of Oklahoma and the Cherokee Nation in December of 2004 ("Settlement Agreement"). Alternative 1 clearly violates the terms of this Settlement Agreement which provides that "SFC will revise the RP to state that raffinate sludge, north ditch sediment, emergency basin sediment, and sanitary lagoon sediment (collectively "Material") located at the SFC site will be disposed of at an appropriate offsite location." Settlement Agreement at pg.4, A.l.a(i). SFC has not revised the Reclamation Plan ("RP") to reflect this change, however, it is beyond dispute that they are required to do so. Contrary to the Settlement Agreement, the proposed action contemplates disposing of all the above listed materials on-site in the disposal cell.	As stated in Section 1.1 of the EIS, as a regulator, the NRC's role in the proposed reclamation of the SFC site is twofold: (1) to ensure that the licensee's (SFC's) proposed action conforms with the public health and safety criteria contained in Appendix A to 10 CFR Part 40; and (2) to evaluate the potential environmental impacts of the proposed action (and any reasonable alternatives) in accordance with NEPA. Accordingly, the NRC staff is reviewing SFC's proposed action against the criteria specified Appendix A to 10 CFR Part 40. This review is documented in a separate SER. NEPA requires Federal agencies to consider the potential environmental impacts of proposed actions in their agency decision making process. The EIS discloses, for public review, the potential environmental impacts, both beneficial and adverse, that would likely result from implementation of the proposed action and reasonable alternatives to the proposed action. The NRC has evaluated an alternative that is in alignment with the Settlement Agreement - Partial Off-site Disposal of Contaminated Materials (Alternative 3). The State of Oklahoma and the Cherokee Nation can use the results of NRC's analysis in support of effectuating the Settlement Agreement. In its role as a regulator, however, the

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Letter/ Comment No.	Comment	Comment Response
		NRC does not identify a preferred alternative. The NRC decision maker will review the EIS, SER, and TER and make a determination as to whether SFC may implement the proposed actions. As per the Settlement Agreement, two months after the publication of the SER by the NRC staff, SFC is required to prepare and submit an updated assessment of off-site disposal locations, SFC's financial resources, and the estimated costs of such off-site disposal. The NRC staff has not yet completed its SER for the SFC proposed action. Once the SER is completed, it is SFC's responsibility to either revise the Reclamation Plan according to the Settlement Agreement or reach consensus with the State of Oklahoma and the Cherokee Nation on other disposal options or modifications to the plan. NRC's role in the EIS process has been clarified in Chapter 1
OAG-2	Additionally, the State disagrees that the impact on Groundwater Resources from Alternative 1 would be "Small." The State asserts that the burying of the most dangerous materials on the site would result in a "Large" impact on the groundwater resources as the leaching of such materials from the cell into the shallow groundwater will cause great environmental harm. The proposed action violates the Settlement Agreement and is not as protective of the environment as Alternatives 2 and 3. Accordingly, the State urges the NRC to reject Alternative 1.	The purpose of the disposal cell design under 10 CFR 40, Appendix A is to isolate contaminants and minimize disturbance and dispersion by natural forces. Please see responses to DOI-2 and DOI-4.
OAG-3	Alternative 2 proposes to dispose off-site of all contaminated materials. The State is in favor of this alternative as removing all contaminated materials off-site greatly reduces the potential harm to the natural resources and people of the State of Oklahoma.	The NRC acknowledges your comment. The text in the EIS has not been changed.
OAG-4	Alternative 3 is similar to the proposed action except that the raffinate sludge, north ditch sediment, emergency basin sediment, and sanitary lagoon sediment will be disposed off-site. Alternative 3 reflects the terms and conditions contained within the Settlement Agreement and the State supports this alternative. SFC agreed, by Settlement Agreement, to amend its RP to reflect this change. SFC has not yet done this and the proposed action violates the Agreement. The State believes that this alternative is more protective of the environment and human health as the most dangerous materials will be disposed of off-site. The potential impacts to Groundwater and Surface water will be lessened by the removal of this material.	As per the Settlement Agreement, two months after the publication of the SER by the NRC staff, SFC is required to prepare and submit an updated assessment of off-site disposal locations, SFC's financial resources, and the estimated costs of such off-site disposal. The NRC staff has not yet completed its SER for the SFC proposed action. Once the SER is completed, it is SFC's responsibility to either revise the Reclamation Plan according to the Settlement Agreement or reach consensus with the State of Oklahoma and the Cherokee Nation on other disposal options or modifications to the plan. NRC's role in the EIS process has been clarified in Chapter 1

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Letter/ Comment No.	Comment	Comment Response
OAG-5	The Settlement Agreement indicated that SFC would excavate all the PCB contaminated soil and dispose of this soil at an approved offsite disposal location in accordance with the applicable requirements in 40 CFR Part 761. The draft EIS did not indicate this for the PCB contaminated soil. The final EIS should include a section describing disposal of PCB contaminated soil.	The information on disposal of PCB-contaminated soil has been added to Chapter 2 of the EIS.
OAG-6	Since there is a potential market for Uranium, SFC should recycle as much of the waste as possible. Specifically, the NRC has just received an application for in situ uranium mining in Wyoming. This application for in situ mining of Uranium in Wyoming and the rising price of uranium indicates that there is a strong market for Uranium. In view of this, and in view of the ability to put "waste" Uranium at SFC to beneficial use by processing it through a Uranium mill, the preferred environmental alternative for waste with substantial concentrations of Uranium at SFC should be to process it through a Uranium mill. This is far preferable to disposing of it in a cell where it will pose a permanent hazard to the area's environment. We understand there is a prospect of SFC actually being paid with a rebate for the reprocessing of such wastes, and this money could be used to further enhance the under-funded cleanup at the Gore facility. If SFC does recycle the Uranium, the remaining waste should be disposed of at an appropriate offsite location. Money from the sale of recycled Uranium could be used for remediation activities.	SFC has been actively pursuing this option. The cost-benefit analysis in the EIS has been updated to include the most recent information available from SFC and a mining facility. The rebate for the uranium has been estimated based on the price of uranium on January 25, 2008. Chapter 7 and Appendix F of the EIS have been revised.
OAG-7	According to NRC's press release regarding in situ uranium mining in Wyoming, the applicant will be required to restore groundwater in the area of mining to background conditions which existed before the mining was done. NRC should make similar requirements of SFC. For almost 30 years, the SFC license for the Gore facility specified that the area would be remediated to the original background levels. This requirement was removed from the license when it came time for the licensee to actually perform the remediation.	As stated in Section 1.3.1 of the EIS, in 2002 the NRC reclassified some of the waste at the SFC site as byproduct material and an license amendment issued by the NRC in December 2002 authorized SFC to possess this reclassified material. With this reclassification, Appendix A of 10 CFR Part 40 (concerning uranium mills and tailings) became the appropriate regulatory regime for site reclamation rather than Subpart E of 10 CFR Part 20 (License Termination Requirements). The on-site disposal cell proposed in SFC's Reclamation Plan meets the performance standards contained in 10 CFR Part 40, Appendix A. Before the site is transferred to either the US government or the State of Oklahoma for perpetual custodial care, the licensee must implement NRC-approved groundwater corrective action measures to the extent necessary to achieve and maintain compliance with the groundwater standards of 10 CFR Part 40, Appendix A. The groundwater *Corrective Action Plan* submitted by SFC is still under NRC review. SFC identified 18 constituents and proposed standards for them; and identified four background, six maximum contaminant levels (EPA drinking water standard), and eight alternate concentration limits. This information has been added to Section 6.1 of the EIS.

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OAG-8	The dust-suppression system discussed in the September 2007 draft EIS appears to be adequate. However, the EIS does not identify the uncontaminated source water that will be used for dust-suppression.	The source of water for SFC's dust-suppression system would be Lake Tenkiller. SFC is permitted to use up to 586 million gallons from the lake each year. It is estimated that the proposed reclamation activities would require 25.3 million gallons per year. In the unlikely event that additional water is needed, it would be obtained from the Illinois River under the provisions of a temporary construction permit to be granted by the Oklahoma Water Resources Board. This information has been added to Section 5.1 of the EIS.
OAG-9	DEQ requirements for the land application of sludge and treated wastewater for the Sequoyah Fuels site are based on requirements that are not "hazards arising from atomic radiation." Currently section 2.2.1.5 of the draft EIS states: If the water still contains relatively high concentrations of nitrates after treatment, the water would be applied to the land application areas at the south end of the SFC site for beneficial reuse. This statement in the EIS does not meet current State of Oklahoma statutory requirements, cited as applicable in the EIS, nor does it meet the OPDES permit requirements issued by the DEQ to SFC. This provision as contained in section 2.2.1.5 should be amended to read: "If the water still contains concentrations of nitrates above 32 mg/L after treatment, the water would be applied to the land application areas at the south end of the SFC site for beneficial reuse at agronomic rates in compliance with the DEQ issued OPDES permit pursuant to 27A O.S. 82-6-501 and Oklahoma Administrative Code (OAC) 252:616-11-1 and 6 16-1 1-2. As stated in the draft EIS, the land application is because of high concentration of nitrates after treatment. Nitrates are not "hazards arising from atomic radiation." Therefore, the NRC does not have "exclusive jurisdiction" over land application and any land application must comply with Oklahoma statutory and permit requirements.	The text in Section 4.3 of the EIS has been revised to indicate that a modification to the permit would be required.
OAG-10	The draft EIS currently makes the following statements concerning wastewaters that are contemplated to flow through Outfall 001 and be discharged into "waters of the state" of Oklahoma: Wastewater generated by SFC during site reclamation (e.g., water from existing ponds and impoundments, storm water runoff from work areas, water used for decontamination and reclamation processes, and recovered groundwater) would be transferred to an existing wastewater treatment system (SFC, 2006a). This wastewater treatment system, which is located south of the clarifier basins, would be designed for batch treatment of wastewater to remove uranium. The system would remove uranium through precipitation, filtration, and ion-exchange processes before discharging the water to permitted Outfall 001. The water would be tested before	The text in Section 2.2 of the EIS has been revised to indicate that a modification to the permit would be required.

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	discharge to ensure that the uranium concentrations comply with the drinking water standards (SFC, 2005). (Emphasis added). See, 4.3.1.1, 4.3.1.2 and 4.3.1.3. The current OPDES permit issued by the DEQ to SFC does not contain any provisions for the discharge of recovered groundwater through Outfall 001. Since the purpose of the OPDES permit is for protection of Oklahoma's Water Quality Standards, as required by federal statute and not for "hazards arising from atomic radiation," such a change in the constituents through Outfall 001 would require a modification of the current OPDES permit. Additionally, any changes in the current treatment system will also need permit modification. Such modifications in the permit may result in different permit limits from the permit limits established in the current permit. Any changes to the system that will modify storm water discharges may also require modification to this permit. To expedite such modifications, SFC will need to submit a detailed proposal to modify their current permit to the WQD of the DEQ at least 180 days before commencing any changes in discharges through permitted outfall(s).	
OAG-11	In Section 4.3.1.4, of the draft EIS, entitled No-Action Alternative states: Measurements of surface water quality in the vicinity of the site indicate that there have been no significant surface water quality impacts as a result of contamination from the SFC facility since operations ceased in 1993. Under this alternative, however, the potential source of future contamination of surface water would not be removed. In the short term, potential direct and indirect impacts on surface water resources would be SMALL. In the long-term, there is the potential for existing contamination to affect surface water resources on the SFC site. Therefore, long-term direct and indirect impacts on surface water resources on the SFC site from implementation of the no-action alternative would be MODERATE. Robert S. Kerr Reservoir is a listed waterbody on the State of Oklahoma's 303 (d) list for impaired waterbodies. Recently, in 2007, SFC has discharged amounts of Nitrogen as Nitrates from its Stormwater Outfall 008 in excess of the permit limit. The permit limit is established to protect the beneficial uses of the waterbody. On three different occasions in the last six months, May, July and August the discharge of Nitrogen as Nitrates has been more than 1.5 times the permit limit. The discharges, in excess of the permit limit, have caused SFC to be in significant non-compliance with the OPDES permit requiring the DEQ to undertake an enforcement action in accordance with the delegation agreement between the DEQ and EPA, Region 6. SFC has stated in correspondence to the DEQ that the cause of the excessive amounts of Nitrogen as Nitrate in the waste stream for Outfall 008 is	The information on exceedances in 2007 has been added to the EIS. The potential impact on surface water for the no-action alternative has been changed from SMALL to MODERATE. Note: MODERATE: Effect is sufficient to alter noticeably, but not destabilize important attributes of the resource

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	coming from Pond 2. The only remedy to these exceedences, according to SFC, is to close Pond 2, which will require NRC license and approval. Due to such high concentrations of Nitrogen as Nitrates being discharged from Outfall 008 and the potential for such future discharges in excess of the permitted limit, the "potential direct and indirect impacts on surface water resources" should be changed from "SMALL" to "GREAT" and the "long-term direct and indirect impacts on surface water resources on the SFC site from implementation of the no-action alternative" should be changed from "MODERATE to "GREAT".	
OAG-12	There are five total retention surface impoundments and eleven flow-through surface impoundments under the current OPDES permit. Any modifications to these surface impoundments would require a permit modification. If SFC's intent is to close any or all of the surface impoundments, a Closure Plan in accordance with OAC 252:616-13 must be submitted to the WQD of the DEQ.	The requirement for a surface impoundment Closure Plan is included in the terms of SFC's State permit and, therefore, has not been repeated in the EIS.
OAG-13	SFC has eleven land application sites totaling 320.2 acres of land. Soils and/or groundwater may be contaminated due to prolonged land application of wastewater. If SFC proposes to cease the land application of wastewater, SFC must submit a Closure Plan in accordance with OAC 252: 61 6-1 3.	The requirement for a surface impoundment Closure Plan is included in the terms of SFC's State permit and, therefore, has not been repeated in the EIS.
OAG-14	The termination of SFC's NRC licenses does not impact the issued OPDES permit. When SFC discontinues the discharge or transfers the facility to a third party, at that time SFC can request a transfer or termination of the OPDES permit. The request for transfer or termination must be submitted separately to the WQD of the DEQ.	The NRC acknowledges your comment. The text in the EIS has not been changed.
OAG-15	The DEIS explains that nitrates in the southern portion of the site will migrate unabated to the Illinois River, and that natural flushing is permitted by the Department of Energy for long-term site control under Title I of Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). See Report, 3-26. Although the report explains that groundwater standards must be met before long-term site control can be transferred to the DOE and that a monitoring plan is being implemented, the nitrates in the southern portion of the site need to be remediated and specifically addressed in the RP and the DEIS.	In the review of SFC's groundwater *Corrective Action Plan*, NRC has observed that remediation of nitrates in the southern portion of the site has not been addressed. NRC will require SFC to address this issue in a revision to the groundwater *Corrective Action Plan*. This information has been added to Section 3.3.2 of the EIS.
OAG-16	The State believes that all provisions of the Settlement Agreement should be incorporated into the DEIS. The following comments [see OAG-17 through OAG-21], without limitation, are required Settlement Agreement provisions which do not appear in the DEIS….The State, by submitting these comments, is not waiving any right to further comment on the DEIS or enforce the terms of the Settlement Agreement with SFC.	The EIS and the SER evaluate the proposed disposal cell design as it is presented in the *Reclamation Plan*. Section 1.3.2 of the EIS acknowledges and references the Settlement Agreement, which is available in the administrative record. Therefore, the terms of the agreement have not been repeated in the EIS. The text in the EIS has not been changed.

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OAG-17	"Technical Specifications: The proposed Cell Construction Technical Specifications will be revised to be consistent with the draft revised Technical Specifications SFC provided to State and CN on October 22, 2004, with the addition of provisions to the effect that the permeability of the clay layers in the cell liner and cap must be 1 x 10-7 or less, contaminated water will not be used for reclamation activities and trees will be eliminated from the vegetative mix on the cover consistent with V.B.4, below," Pg.8(B)(3). The DEIS does not reflect this and should be changed to reflect the terms of the Settlement Agreement.	The technical specifications of the proposed cell construction in the *Reclamation Plan* are addressed in the SER. Section 1.3.2 of this EIS acknowledges and references the Settlement Agreement, which is available in the administrative record. Therefore, the terms of the agreement have not been repeated in this EIS. The text in the EIS has not been changed.
OAG-18	"Separation From Groundwater: SFC will maintain at least a five foot separation between the waste in the cell, including leachate, and the highest measured groundwater level at any point under the cell as established by water level measurements SFC has taken since 1990." Pg.8(B)(5). The DEIS does not reflect this and should be changed to reflect the terms of the Settlement Agreement.	Please see response to comment OAG-17.
OAG-19	"Sumps: The design of the leachate collection sumps will be revised to provide for welding the synthetic line to the leachate collection pipe, double wall pipe, and with a liner to pipe joint design that is designed to withstand anticipated differential settlement." Pg.9(B)(6). The DEIS does not reflect this and should be changed to reflect the terms of the Settlement Agreement.	Please see response to comment OAG-17.
OAG-20	"Leak Detection: The disposal cell described in the RP is underlain by a leak detection system under the synthetic cell base liner. SFC will not make changes to this design unless the NRC finds that an alternative design provides a satisfactory level of protection for public health, safety, and the environment which is equivalent to, or more stringent than, the level which would be achieved by compliance with Appendix A to 10 CFR Part 40, SFC agrees that if it does propose a change to this design, such proposal would constitute new information, as that term is discussed in III.B.1, above. Pg.9(B)(7). The DEIS does not reflect this and should be changed to reflect the terms of the Settlement Agreement.	Please see response to comment OAG-17.
OAG-21	"Point of Compliance Wells: Two proposed disposal cell point of compliance wells will be added, one of which will be placed near the Phase II cell section leachate collection sumps on the southwest corner of the cell and the other will be placed along the south side of the cell. SFC will sample all point of compliance wells quarterly." Pg.9(B)(8). The DEIS does not reflect this and should be changed to reflect the terms of the Settlement Agreement.	Please see response to comment OAG-17.

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State of Oklahoma Water Resources Board (Letter dated 11/5/07; ADAMS ML073110103)		
ORB-1	The draft EIS does not address or estimate the amount of water needed to carry out the proposed reclamation activities, nor does it address any proposals regarding the ultimate disposition of the water right issued by the OWRB or the storage contract entered into by the Corps of Engineers. These items are extremely important factors in assessing long-range water planning for east central Oklahoma and must be addressed before any approval of the transfer or release of any portion of the site is considered. In the meantime, the SFC should contact the OWRB to discuss the status of the water right to ensure a sufficient amount for reclamation activities is still authorized.	See response to comment OAG-8.
ORB-2	On a separate matter, we note that information in the report explains that nitrates in the southern portion of the site will migrate unabated to the Illinois River, and that natural flushing is permitted by the Department of Energy for long-term site control under Title I of Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). See Report, 3-26. Although the report explains that groundwater standards must be met before long-term site control can be transferred to the DOE and that a monitoring plan is being implemented, Oklahoma cannot take responsibility for detrimental effects that "natural flushing" may have on area water resources. Furthermore, Oklahoma cannot take responsibility for the quality of the water affected by the natural flushing of nitrates or from other contaminants emanating from the SFC facility that flows from Oklahoma into the State of Arkansas.	NRC acknowledges this comment. As stated in Section 3.3.2 of the EIS, the NRC is requiring SFC to address the issue of nitrates migrating to the river in a revision to the groundwater *Corrective Action Plan*.
Horace Lindley, Administrator for the Town of Gore (Oral Testimony 10/16/07; ADAMS ML072980315)		
HL-1	We would like to express that our immediate concern about the environmental impact of any reclamation or corrective activities is primarily focused on our citizens, health and welfare.	A significant portion of the EIS looks at impacts to the public and affected environment as a result of the proposed action (reclamation). Regarding longer term concerns, please see response to comment DOI-1.
HL-2	We also must take into consideration how property values have been or will be affected by these activities.	With the reclamation of the SFC site, including completion of the groundwater *Corrective Action Plan*, there would be no impacts on current and future property values in Sequoyah County. Release of a portion of the site for unrestricted use (including potential commercial or industrial reuse) could potentially have long-term economic benefits given the proximity of the site to the Illinois and Arkansas rivers and Interstate 40. The text in Section B.6 of the EIS has been modified.
HL-3	And what affect might proposed actions have on our tourism? Caution must be used to protect our rivers, lakes, fishing/boating/camping activities and our area's ecology. The town also has a concern about the long-term economic impact the reclamation or corrective activities might have. We must take into account the effect, on our generation of revenue.	With the reclamation of the SFC site, including completion of the groundwater *Corrective Action Plan*, there would be no impacts on current and future tourism opportunities in Sequoyah County. The demolition of the buildings and equipment currently present on-site would improve the visual aesthetics. The proposed disposal cell would be constructed in accordance with the

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		stringent design criteria in Appendix A to 10 CFR Part 40, which are protective of public health and safety. In the short-term, following reclamation, there would likely be no change in the existing economic conditions. However, release of a portion of the site for unrestricted use (including potential commercial or industrial reuse) could potentially have long-term economic benefits given the proximity of the site to the Illinois and Arkansas rivers and Interstate 40. The text in Section B.6 of the EIS has been modified.
HL-4	Our local educational needs must be taken into consideration. Our town's infrastructure must not suffer from actions necessary to continue the clean up at the site in question. We feel there is a direct correlation between the environmental and economic issues. The town must partner with the NRC to formulate a solution to address the local impact concerns and to provide remedies where the situation may warrant. We seek the support and assistance of state and federal programs to mediate environmental and economic impact.	The cleanup of the site and release of a portion of the site for unrestricted use could potentially provide long-term economic and tax benefits to Sequoyah County given the proximity of the site to the Illinois and Arkansas rivers and Interstate 40. The text in Section B.6 of the EIS has been modified.
Ryan Callison: The Cherokee Nation's Environmental Group (Air Quality Manager) and Mayor of Gore (Oral Testimony 10/16/07; ADAMS ML072980315)		
RC-1	So I would just stress that you keep in mind the working relationship with the tribe. The tribe has a lot of infrastructure and over 50 Environmental Specialists that can provide support to the NRC and DOE past -- after one of these actions is taken.	The Cherokee Nation is a Cooperating Agency. Their comments have been considered in the development of this EIS.
Jeanine Hale, Senior Assistant Attorney General, Cherokee Nation (Letter dated 4/16/08; ADAMS ML 081210295)		
CHN-1	The binding settlement agreement between Cherokee Nation, State of Oklahoma and Sequoyah Fuels (SFC) requires the offsite disposal of certain wastes as described in the draft EIS's Alternative 3. We realize that NRC is not recommending the selection of any one alternative, but we continue to take the position that Alternative 3 should be considered the proposed action. It is not logical or efficient for NRC to prepare and finalize an EIS and/or a SER based upon a Reclamation Plan that is going to be modified in the near future.	See response to comment DOI-4. The NRC staff has evaluated Alternative 3 in the EIS. If the Reclamation Plan is modified, the NRC will evaluate whether a supplement to the EIS is necessary.
CHN-2	Many of our concerns, and the concerns of the public, would be better addressed if the EIS were revised to more accurately consider the relative impacts and costs/benefits of a reclamation plan based upon offsite disposal.	The cost benefit analysis (Chapter 7 and Appendix F) has been performed for all three alternatives, including the off-site disposal alternative. The text in the EIS has not been changed.
CHN-3	The Cherokee Nation continues to take the position that the potential environmental impacts (socio-economic, ecological, biological, cultural, and water resource-related) will be substantially less if the most highly contaminated wastes are removed from site, the disposal cell is smaller	The impacts are the same for Alternatives 1 and 3 because in both cases the contaminated materials will be contained within an engineered disposal cell. The public and worker radiation doses for both alternatives are below regulatory limits. If there were a loss of institutional controls within the

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	and the risk to human health and the environment from leakage/migration of contaminants from the cell is reduced significantly because the radiation hazard is lower.	proposed ICB following reclamation, the estimated dose to the public would be within regulatory limits for Alternative 1, as demonstrated using a resident farmer scenario in which the farmer resides on the land within the ICB (see Section 4.4 and Appendix D). Also, see response to comment DOI-2.
CHN-4	The EIS should address the difference between the time that the integrity of the disposal cell's liner and monitoring system can be predicted to remain sound and the time for the complete degradation (including consideration of the half life of various constituents contained in the cell) or dissipation of all contaminants.	See response to comment DOI-1.
CHN-5	The current version of the EIS does accurately point out that the nitrate plume is not adequately addressed in the current Reclamation Plan or the Groundwater Corrective Action Plan.	See response to comment ORB-2.
CHN-6	The section about considering other technologies should be expanded to include consideration of, or a recommendation that others study and provide to NRC the results of a study of, other technology available for extracting or remediating nitrates and all other non-radiological constituents that contaminate the groundwater, soils or surface waters & stream sediments in the area of the SFC industrial site.	The final NRC-approved groundwater Corrective Action Plan will require the restoration of groundwater to EPA standards as per the requirements of 10 CFR 40, Appendix A. The groundwater cleanup standards must be met before the SFC site can be transferred to a long-term custodian, either the State of Oklahoma or the United States government. The text in the EIS has not been changed.
CHN-7	The EIS should consider how various alternatives for future monitoring and re-evaluation of the success of the selected alternative might help avoid environmental impacts or provide new information needed to develop proposals to revise and improve remedial activities.	Following reclamation and cleanup of the groundwater, the site will be turned over to the U.S. government or the State of Oklahoma under a general license to the NRC. Long-term monitoring of the groundwater and oversight of the facility is planned and will be required as a condition of the license. Long-term maintenance and surveillance requirements will involve annual inspections and maintenance activities to ensure the performance and longevity of the site. Annual inspection schedules and annual monitoring reports of legacy sites are made publically available by the U.S. Department of Energy (the only current custodian of all legacy sites). The Department of Energy requirements for legacy sites include responding to stakeholder inquires for each site, which could include inquires about the need for future remediation, if necessary. The text in the EIS has not been changed.
CHN-8	The EIS still does not adequately address impacts to Native Americans under the Environmental Justice topic. It does not matter how far away the census tracts with the greatest populations of Native Americans are if they travel to the SFC area to fish, gather crayfish or mussels, collect plants or obtain water for medicinal purposes. That is why we earlier suggested an evaluation of the "lifeways" of Native Americans in the	The purpose of the EIS is to evaluate the impacts of the licensee's proposed action and any reasonable alternatives. The proposed action for reclamation of the site will result in removal of the contaminated soil and cleanup of the groundwater at the SFC site. The contaminated materials will be fully contained within an engineered disposal cell, and access to the cell will be restricted through the creation of an ICB. Therefore, the impacts on Native

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	area.	Americans will actually be reduced from current conditions. Section 4 of the EIS evaluates the impacts during and following reclamation. The text in the EIS has not been changed.
CHN-9	Ecological Resources: there is inadequate description of Fish and Wildlife resources associated with riparian areas and aquatic habitats, such as fish, mussels, and amphibians. This topic should be broader than just a discussion about endangered species or habitat.	The aquatic species in the rivers and the recreational uses of the rivers are discussed in Sections 3.2.1 (Land Uses at the Sequoyah Fuels Corporation Site) and 3.3.1.2 (Surface Water Uses). A short discussion regarding the types of amphibians, reptiles, and mussels has been added to B.5, Ecological Resources and Impacts (Section B.5.1.3).
CHN-10	The EIS should address cumulative impacts resulting from surface water contamination by nitrates and other forms of nitrogen (and possibly other constituents such as arsenic, uranium or phosphorus) from several sources in the area. For example, potential sources of nitrogen compounds include the SFC-related land application program, wastewater discharge, impoundments, contaminated soils, and groundwater plumes associated with the SFC site, combined with other sources in the area such as use of inorganic fertilizer for crops, confined animal feeding operations, land application of poultry litter, septic tanks, wastewater treatment systems and urban runoff.	A qualitative discussion of the long-term cumulative impacts resulting from surface water contamination in the Illinois River Basin has been added to Section 4.6, Cumulative Impacts.
CHN-11	The EIS does not rank the costs/benefits of the alternatives in a manner that shows that offsite disposal will have greater benefits. This is in error. There will be fewer risks and impacts and greatly benefits to every aspect of the environment if the most highly contaminated wastes are removed from the site.	Many factors are included in a cost-benefit analysis covering several alternatives. In this case, the analysis includes impacts on the public and environment from the placement of an on-site disposal cell, in addition to the impacts from transportation of all of the material or a portion of the material to an off-site disposal site. The results of the cost-benefit analysis are provided in Chapter 7. The text in the EIS has not been changed.
CHN-12	The EIS should be revised to include a more complete description of the interests of the Cherokee Nation, Cherokee laws and the possible nature of the Nation's involvement as long-term stewards under a general NRC license or under contract with DOE. The Cherokee Nation has a strong interest in making sure that the site is properly monitored and maintained long after the reclamation and groundwater corrective action plans have been implemented, for the purpose of protecting our citizens and resources.	The Cherokee Nation or any other interested stakeholders are encouraged to examine the long-term maintenance and surveillance plan that will be developed by either the State of Oklahoma or the U.S. government for the SFC site. It should be noted that the U.S. government (Department of Energy [DOE]) is the only entity that has taken custody of legacy sites in the U.S. The long-term surveillance requirements of legacy sites involve annual inspections and maintenance activities to ensure the performance and longevity of the site. Annual inspection schedules and annual monitoring reports of legacy sites are made publically available by the DOE. DOE requirements for legacy sites include responding to stakeholder inquiries. All stakeholders who have an interest in the proper maintenance and monitoring of the SFC site can inquire about opportunities for additional involvement through the DOE's Legacy Management Office - http://www.lm.doe.gov/

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		The text in the EIS has not been changed.
Ed Henshaw, Private Citizen (Letter and Oral Testimony 10/16/07; ADAMS ML073101178 and ML072980315)		
EH-1	The EIS is obviously written to protect the monetary interests of SFC and not the intended purpose of an environmental impact statement; which is to protect the environment and public health.	This EIS, which addresses reclamation of the SFC site, has been prepared in accordance with applicable NRC and Council on Environmental Quality (CEQ) guidance. It provides decision makers and the public with a detailed and objective evaluation of the potential environmental impacts, both beneficial and adverse, that would likely result from implementation of the proposed action and or its reasonable alternatives. In its role as a regulator, however, the NRC does not identify a preferred alternative. The NRC decision maker will review both the EIS and SER and make a determination as to whether SFC may implement the proposed action. The text in Section 1.1 of the EIS has been changed to clarify NRC's role.
EH-2	It also ignores the fact that wastes from this site have already migrated into those waters.	Nitrates in surface water have recently shown exceedances approximately 1.5 times the permitted levels in one outfall, which has been addressed in Section 3.3 of the EIS. The EIS discusses the fact that contaminants, such as uranium, nitrates, fluorides, and arsenic, have migrated into the terrace and shallow bedrock aquifers and that arsenic has been detected in the deep bedrock aquifer. Although some contaminants from the site have reached the Illinois River, the effects of river dilution have rendered those contaminants either undetectable or at levels well below drinking water standards. The purposes of the proposed action and the groundwater Reclamation Plan are to isolate the wastes from the surface and ground water systems and clean up existing groundwater contamination, which should help minimize future impacts to the river. This information is provided throughout the EIS.
EH-3	Conversely the illegal use of the deep injection well proved that the different geological units are inter-connected and provide a conduit- for mixing of ground waters from different geological strata.	Appendix G of the EIS contains a description of the deep injection well program. In summary, the Oklahoma Department of Health, Industrial Waste Division issued a permit on October 19, 1982 for operation of a deep-injection well at the SFC site for the disposal of treated liquid raffinate into the Arbuckle Formation (between 1,619 and 3,122 feet below ground surface). The NRC amended the site license to authorize the injection of treated raffinate liquid (radium levels less than 5 pCi/L) subject to an initial volume limit of 5 million gallons followed by monitoring tests of formation performance. The test results were submitted to Oklahoma and the NRC for permission for continued injection. The injection well, however, was abandoned and plugged in 1985. The history of the deep injection well at the SFC site is included in Appendix G.

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		Summary information regarding the deep injection well has been added to Chapter 2 of the EIS.
EH-4	The property has fault lines traversing it with attendant risks. Another obvious omission is the failure to address the artesian water sources that originate in lower geological formations and surface on site and are evidenced by briny solutions.	There are no known active faults within 100 kilometers (62 miles) of the SFC site. The Carlile Fault, which is located to the southeast of the SFC site, is a non-capable fault (see Section B.3 of the EIS). The EIS discusses the impacts of contaminant transport across the site and into the Illinois River via surface water and groundwater in the terrace, shallow bedrock and deep bedrock systems. Briny solutions welling up from the deeper Arbuckle formation (1619 feet below ground surface) do indeed indicate artesian water flow. The artesian flow is minor and has little to no influence on the migration of SFC contaminants across the site. This information has been added to Section 3.3.2 of the EIS.
EH-5	The wastes at this site were intentionally misclassified and should never be placed in a region where there is the remotest possibility of contaminating potential drinking water sources. The wastes here are not mill tailings but instead refined and concentrated amounts of radionuclide and numerous heavy metals.	The NRC acknowledges your comment. The text in the EIS has not been changed.
EH-6	The authors of this document suggest that the groundwater near this site will never be used because of the close proximity of the river.	In the groundwater impact section of the EIS, it is stated that the groundwater could be used in the future, however, the Atoka Formation, which underlies the SFC site, has a limited potential as a groundwater source. Calculated yield rates are low (only a few gallons per minute) and the predominant shales contribute to high sulfate levels (1,750 mg/L) and total dissolved solids concentrations of greater than 3,100 mg/L. For future domestic water consumption, the existing rural water distribution system (specifically Sequoyah County Rural Water District No. 5), which draws water from Lake Tenkiller would be a more likely source of water due to its better quality and reliability. Any water used locally for irrigation or livestock would likely come from the Illinois River due to its better quality and predictable yields. Of the existing wells located within 3 kilometers of the site, none of them are hydraulically downgradient of the site, i.e., groundwater in the vicinity of the site flows away from the wells. This information has been added to Section 4.3.2 of the EIS.
EH-7	Why are Sequoyah Fuels, General Atomics, and Kerr McGee Corporation not paying to properly dispose of this material? It should be placed in a dry climate, totally segregated from any potential drinking water sources.	Please see response to comment OAG-7.
EH-8	At present, not one of the EISs produced by the AEC or NRC that relates to the license of this facility is worth the paper it is written on. Not one of them has been substantiated in practice nor has one proven to be valid.	Please see response to comment EH-1.

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	Extreme environmental contamination has resulted after each and every assurance that 'no adverse environmental impacts are anticipated' due to the respective license amendment. The NRC has no credibility left. In the approximately 25 year operational life span of this facility, every waste impoundment that I know of at this site, and approved by the NRC, has failed and spewed toxic or radioactive waste into the groundwater and surface waters adjacent to this facility. Some went unaddressed for more than a decade while the NRC and other dilatory regulatory agencies sat idly by.	
EH-9	How you intend to isolate these hazardous wastes from the ground and surface waters for the billions of years of their half-life (Ra226 =1600 years, Th230=75,400 years, and U238=4.46 billion years)?	Please see response to comment DOI-1.
EH-10	SFC is seeking approval to bury 198.6 curies of radionuclides that are packaged and ready for shipment to a proper disposal site in spite of an agreement with the State of Oklahoma to ship them there.	Please see response to comment OAG-1.
EH-11	I personally think the NRC cannot legally dispose of low level radioactive waste in Oklahoma since it is a member of the Central States Low Level Waste Compact and was not designated as the repository state for such wastes.	Some of the waste has been classified as 11e.(2) and SFC's proposal is in accordance with 10 CFR Part 40, Appendix A. The remaining waste can be disposed of with the 11e.(2) waste in accordance with NRC guidance (see SER Chapter 7). Specifically, the Central Interstate Low-Level Waste Compact does not require approval to dispose of low-level waste at the generator's own site. The text in the EIS has not been changed.
EH-12	How much will it cost to remediate the largest freshwater aquifer in the State of Oklahoma, not if, but when it becomes contaminated with the leachates from this burial site and who will bear the burden of that expense?	Please see response to DOI-2. Although the Illinois and Arkansas rivers constitute a large surface water resource in eastern Oklahoma, they do not constitute the largest freshwater aquifer system in the State of Oklahoma. The following USGS Web site shows the major alluvial and bedrock aquifers: http://ok.water.usgs.gov/gis/aquifers/
Nadine Barton: Citizens Action for a Safe Environment (Oral Testimony 10/16/07; ADAMS ML072980315)		
NB-1	For the long-term maintenance of the cell in the restricted area Sequoyah puts up approximately $250,000 in money in 2007 dollars. And that goes for 1,000 years. I don't know about you, but I don't have much faith in that. So how is that going to be maintained for all of that time?	The $250,000 (1978 dollars; Criterion 10 of 10 CFR Part 40, Appendix A) is $798,000 in 2007 dollars as indicated in Appendix F of the EIS. The $798,000 was used for purposes of the cost benefit analysis to compare various options. This amount is present for all on-site disposal cell options, but not for Alternative 2, total off-site disposal. As stated in Criterion 10 to Appendix A to 10 CFR Part 40, "the total charge to cover the costs of long-term surveillance must be such that, with an assumed 1 percent annual real interest rate, the collected funds will yield interest in an amount sufficient to cover the annual costs of site surveillance." The disposal cell design requirements in 10 CFR 40, Appendix A are such that routine maintenance of the cell is not

Table H-1 PUBLIC COMMENTS ON THE DEIS AND NRC STAFF RESPONSES

Letter/ Comment No.	Comment	Comment Response
		required. Additional upfront money from SFC can, however, be required by NRC and DOE if routine maintenance, such as the biannual cutting of trees on the cell, is required as part of the NRC general license. The upfront money goes into the US Treasury and DOE receives needed money for legacy site surveillance and any required maintenance through appropriations from Congress. The text in the EIS has not been changed.
NB-2	Do we think that within 200 to a thousand years that the leachate from that hole that is lined with clay is not going to be penetrated by ground water and surface water over that time and finally, as Ed said, go into the Arkansas and the Illinois Rivers? Who is going to clean that up? Sequoyah Fuels maintains approximately 276 acres for unrestricted use. That means that 75 years from now housing developments can be built there. Schools can be built there. Hospitals can be built there. Day care centers can be built there.	Please see response to comment DOI-2.
NB-3	There should be some kind of notification to the public that when they're going to be disturbing the soils. And I concur with Mr. Henshaw, this is not mill tailings. This is hot stuff that was used to make the fuel for nuclear reactors. It's not mill tailings. This is refined.	The licensee will comply with best management practices to control air emissions such that no off-site airborne contamination would occur above applicable public health and safety limits. Please see response to comment EPA-1. This information has been added to Section 5 of the EIS.
NB-4	Are we going to have security around the area? You know this is on the website. And I hate to bring that up, but we live in a time that God would never have foreseen for this country that we have to guard places where they have low level radioactive waste from terrorists coming in. So the people that work on that, gentlemen, are they going to be screened and background checks to make sure that they have no affiliations that some of this material could possibly - escape into the wrong hands here in Oklahoma?	A security fence will be installed at the institutional control boundary (ICB). In addition, there would be custodial care and deed provisions that would secure the site and minimize the potential for recreational access or other uses of the property within the ICB. Once the cell is built, an intruder would not have ready access to the waste inside the cell. Heavy equipment such as a bulldozer or front end loader would be needed to unearth any contaminated material. The text in the EIS has not been changed.
NB-5	You know it takes water to attract economic development. And if you contaminate this water, who in their right mind would want to come here and locate an industry knowing that this extravaganza is going? We have hard enough time attracting industry here. And water is the key issue. There are people going all over the United States and the world that are called water brokers that are buying up good water because that's going to be more important than any oil.	The proposed disposal cell would be constructed in conformance with the stringent design criteria in 10 CFR Part 40, Appendix A, which are protective of public health and safety. Release of a portion of the site for unrestricted commercial or industrial reuse would have long-term economic benefits given the proximity of the site to the Illinois and Arkansas rivers and Interstate I-40. This information has been added to Section B.6 of the EIS.

NRC FORM 335 (9-2004) NRCMD 3.7	U.S. NUCLEAR REGULATORY COMMISSION	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

Sequoyah Fuels Corporation (SFC) is proposing to conduct reclamation activities at its 243-hectare (600-acre) former uranium conversion site in Gore, Oklahoma. SFC proposes to consolidate contaminated sludges and soils, demolish existing site structures, and construct an engineered, above-grade, on-site disposal cell for the permanent disposal of all site contaminated materials. SFC also has submitted to the NRC a groundwater corrective action plan for the purposes of recovering and treating site groundwater contaminated by prior site operations, with the goal of reducing concentrations of identified hazardous constituents to the NRC-approved concentration limits for each constituent.

This Environmental Impact Statement (EIS) was prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 and NRC regulations for implementing the Act found at Title 10, "Energy," of the U.S. Code of Federal Regulations (CFR), Part 51 (10 CFR Part 51). This EIS evaluates the potential environmental impacts of the proposed action and its reasonable alternatives. This EIS also describes the environment potentially affected by SFC's proposed site reclamation activities, presents and compares the potential environmental impacts resulting from the proposed action and its alternatives, and describes SFC's environmental monitoring program and mitigation measures.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

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