SEQUOYAH FUELS
A GENERAL ATOMICS COMPANY

FINAL DECOMMISSIONING ALTERNATIVES STUDY REPORT

June 8, 1998

Final Decommissioning Alternatives Study Report

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Final Decommissioning Alternatives Study Report

1.0 Introduction

In February 1993, Sequoyah Fuels Corporation (SFC) notified the Nuclear Regulatory Commission (NRC) of its decision to terminate activities authorized by its source materials license SUB-1010 and requested termination of that license. At the same time, SFC submitted a Preliminary Plan for Completion of Decommissioning (PPCD) of the SFC Facility. The PPCD described a decommissioning approach which included onsite disposal of all decommissioning wastes in an engineered cell and restricted release of a portion of the site containing the disposal cell. On August 3, 1993, the Environmental Protection Agency issued a Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent (AOC) to SFC. The AOC included the requirement to perform a Corrective Measures Study (CMS) to develop remediation plans for cleanup of the RCRA constituents of concern at the Facility.

Until recently, licensees were required by NRC regulations to decommission their facilities once licensed activities ceased so that the property could be released for unrestricted use. For SFC, the criteria for allowing release of sites for unrestricted use are listed in NRC's *Action Plan to Ensure Timely Cleanup of Site Decommissioning Management Plan* (SDMP) (57 FR 13389; April 16, 1992), and require that radioactivity in buildings, equipment, soil, groundwater, and surface water resulting from the licensed operation be reduced to acceptably low levels. Licensees must then demonstrate, by a site radiological survey, that residual contamination in all facilities and environmental media has been properly reduced or eliminated and that, except for any residual radiological contamination found to be acceptable to remain at the site, radioactive material has been transferred to authorized recipients. Confirmatory surveys are conducted by NRC, where appropriate, to verify that sites meet NRC radiological criteria for decommissioning. Alternatively, NRC could approve onsite stabilization of the radioactive material if land-use restrictions or other institutional controls are used to ensure long-term protection of the public and the environment. Onsite stabilization would require an exemption from NRC's decommissioning requirements for any such restricted release of the site. This in turn would require the NRC to prepare an Environmental Impact Statement (EIS) on this action.

In October, 1995, the NRC published a Notice Of Intent to prepare an EIS for SFC's proposed decommissioning plan, and subsequently conducted a scoping meeting. On January 31, 1996, in response to concerns expressed by SFC regarding the schedule and cost of the planned EIS, the NRC staff sent SFC a letter that identified the information SFC should submit to support the NRC's preparation of an EIS. Largely in response to the January, 1996 letter, SFC initiated a decommissioning alternatives study to evaluate alternatives available for decommissioning the Sequoyah Facility. The scope of the study covered a range of options, including the preferred option of on-site disposal identified by SFC in the PPCD, and the "no-action" alternative required by National Environmental Policy Act (NEPA). Conceptual designs and cost estimates were prepared for the major decommissioning activities and, from these, implementing costs developed for each option. The study also included the development of site-specific cleanup criteria to delineate the type, quantity, and contamination level of materials that could be isolated onsite and consideration of the method of isolation. This Decommissioning Alternatives Study Report (DASR) was submitted to the NRC in draft form in December, 1996.

In July, 1997, the NRC published a new license termination rule which changed the criteria for decommissioning. The provisions of the new license termination rule allow licensees to follow one of several different approaches to decommissioning including restricted release of a site with residual radioactive materials left in place. SFC has reviewed the new rule and has determined that the preferred decommissioning approach presented to the NRC in the draft DASR can be accommodated under the new regulations. Thus, no major changes to the proposed approach were made. In addition, it appears now that no exemption will be required for restricted release which is proposed for a portion of the site.

This final DASR presents the results of the decommissioning alternatives study, including additional studies contemplated in the Draft DASR, and provides technical information in support of the preferred option to construct a disposal cell for the permanent isolation of decommissioning waste from the Sequoyah Facility. The non-radiological impacts to SFC property are not fully addressed in this document. Impacts to the facility groundwater from nitrates and fluoride will be addressed separately with the State of Oklahoma. All RCRA impacts which include arsenic in facility groundwater will be dealt with through the AOC signed with the US EPA.

1.1 Background and Purpose of Study

In 1970, SFC began operation of a uranium conversion industrial plant located about 2.5 miles southeast of Gore, Oklahoma, north of Interstate Highway I-40 and west of Oklahoma State Highway 10. In 1987, SFC began operation of a plant for the reduction of depleted uranium hexafluoride (DUF_6) to depleted uranium tetrafluoride (DUF_4). SFC formally discontinued production operations in July, 1993. On February 16, 1993, and July 7, 1993, pursuant to 10 CFR 40.42, SFC notified the Nuclear Regulatory Commission (NRC) of its intent to terminate licensed production activities at the Facility and requested termination of source materials license SUB-1010. Also on February 16, 1993, SFC submitted a Preliminary Plan for Completion of Decommissioning (PPCD) of the facility.

During the time of operations, SFC disposed of contaminated material on-site in accordance with 10CFR20.304 and constructed and utilized numerous settling and storage ponds. Operations also impacted the surrounding soil and groundwater.

In response to concerns in the early 1990's about the extent of environmental contamination, SFC performed a Facility Environmental Investigation (FEI). The FEI provides detailed information about the extent of contamination at the facility. Additionally, SFC has conducted a comprehensive site characterization program to expand on the FEI and to further identify existing radiological and chemical contamination in partial fulfillment of NRC and Environmental Protection Agency (EPA) requirements. Information describing the extent and concentration of radiological contamination at the site was provided in the Draft Site Characterization Report submitted to the NRC on February 2, 1996 and in the Final RCRA Facility Investigation Report submitted to the EPA on October 14, 1996.

1.2 Constituents of Concern (COCs)

COCs are the constituents detected at the SFC site that have the potential to pose a hazard to humans or the environment and are evaluated in the derivation of site-specific cleanup levels.

Based on historical information and findings of the site investigations, the potential radiological COCs for soil, surface water, sediment, and groundwater were determined to be natural uranium (U_{Nat}), and the associated decay products, thorium (Th)-230 and radium (Ra)-226. For protection of human health and the environment, cleanup criteria were derived or determined from literature for radium-226, thorium-230 and U_{Nat}.

Additionally, the potential chemical COCs identified for the site in previous investigations are arsenic, barium, fluoride, PCBs, and nitrate. Other chemical constituents appear to be below levels of regulatory concern. Since these chemical constituents do not fall under the NRC's regulatory authority, the USEPA and the Oklahoma Department of Environmental Quality (ODEQ) will be responsible for final determination of what, if any, remediation of the these chemical constituents of concern must be initiated. Generally, the sludges and soils that are impacted by these chemical constituents are also impacted by radiological constituents, therefore methods of the removal, treatment, and on-site disposal of sludges and soils described in SFC's proposed decommissioning alternative are applicable.

SFC also believes that for groundwater, monitored natural attenuation of these chemical constituents is adequately protective of human health and the environment.

1.3 Structure of Report

This report presents the findings of the Decommissioning Alternatives Study. Section 2 of this report provides a description of SFC's proposed decommissioning approach, including the conceptual design for the proposed on-site disposal cell. Proposed site-specific cleanup criteria are presented in Section 3 along with the bases for the proposed criteria. Section 4 provides descriptions of each of the decommissioning alternatives considered. Updated environmental information is provided in Section 5, and a cost benefit evaluation for the proposed approach and each of the alternatives considered is presented in Section 6. A discussion of additional studies identified during preparation of this report is provided in Section 7.

Copies of the individual engineering reports developed during the study are included as appendices to this report.

1.4 Prerequisites to Decommissioning of the SFC Site

It is assumed that the following actions will have been completed prior to commencement of full-scale decommissioning of the SFC facility.

- Issuance of the Final EIS and Record of Decision (ROD) for the SFC site.
- SFC Decommissioning Plan finalized and approved by license amendment by the NRC.
- DUF_4 slag returned to the U.S. Government or shipped to an approved disposal site.
- Heels removed from UF_6 cylinders or UF_6 cylinders removed from site.
- Regulated asbestos containing materials will be removed from equipment and structures and packaged for compaction/disposition.
- EPA remedies for RCRA constituents selected (projected to be removal and treatment of source material prior to on-site disposal and monitored natural attenuation of groundwater).

- An Interim Groundwater Monitoring Plan (and associated, approved license amendment) in place to allow removal and plugging of monitoring wells under the footprint of the disposal cell and in areas requiring excavation.

2.0 Description of Proposed Decommissioning Approach

2.1 Summary Description

SFC's proposed decommissioning approach will result in the release of the property outside the current Process Area for unrestricted use with respect to residual radioactive materials, and the restricted release of the remainder of the site. The proposed approach includes complete dismantlement of all facility equipment and structures, remediation of sludges, impoundments, buried wastes and certain impacted soils, and placement of all resulting waste materials in an on-site, engineered disposal cell. Radiologically impacted groundwater contained in the terrace deposits and perched on the bedrock surface underlying the Process Area will be recovered to the extent practical, treated and released. Radiologically impacted groundwater in the Shallow Bedrock Groundwater System will not be recovered. Instead, it will be allowed to remediate naturally through monitored natural attenuation.

Deconstruction activities will be conducted in a sequence which allows construction of the cell as the decommissioning progresses and minimizes the handling of the waste materials. The disposal cell will provide for isolation of all contaminated material in order to minimize the potential exposure to individuals as well as to prevent migration of the isolated material into a human exposure pathway. When all contaminated waste material has been placed in the onsite disposal cell, the cell will be closed. The cell closure will include the covering of the contents with an engineered cap in order to limit the intrusion of water into the disposal cell and the diffusion of radon into the atmosphere. The cover will be designed to prevent wind and water erosion, and reduce the possibility of intrusion by animals or humans. The cell and cap will also be designed to withstand significant damage from the maximum anticipated seismic event for the site. Additional institutional controls will be imposed upon the disposal cell and buffer zone around the cell to control access to the restricted portion of the site.

SFC's preferred decommissioning approach consists of the following elements:

- Construction of an above-grade, engineered disposal cell on the SFC site for permanent disposition of the SFC decommissioning wastes.

- Removal and treatment of raffinate sludge, calcium fluoride sludge, Pond 2 residue, and sediments from the Sanitary Lagoon, North Ditch and Emergency Basin followed by placement into the disposal cell. Excavation and treatment of buried low-level wastes, Pond 1 spoils and material from the Interim Soils Storage Cell.

- Dismantlement of process equipment, followed by recovery of gross quantities of contained uranium.

- Dismantlement/demolition of structures excepting the new SFC administrative office building and the storm water impoundment.

- Size reduction/compaction of process equipment, piping and structural materials (including scrap metal, empty drums, and packaged wastes that will accumulate prior to decommissioning) to satisfy disposal requirements for maximum void volume.

- Demolition of concrete floors, foundations, asphalt or concrete paved roadways and selected concrete pads in the restricted areas. Removal of contaminated soils and/or clay liners from under impoundments.

- Excavation and treatment of underground utilities, contaminated sand backfill from utility trenches and building foundation areas and more highly contaminated soils under the cell footprint.

- Excavation of contaminated soils lying outside the footprint of the disposal cell that exceed site-specific radiological criteria.

- Recovery and treatment of radiologically impacted terrace and perched groundwater.

- Placement of all SFC decommissioning wastes into the onsite disposal cell, followed by capping and closure of the cell.

- Backfilling of excavations to a finished grade, addition of topsoil and re-vegetation.

- Establishment of a fenced institutional control boundary around the cell, installation of additional monitoring wells as necessary, and initiation of a long-term site monitoring plan.

- Monitored natural attenuation of contaminants in the shallow bedrock groundwater system.

- Establishment of an agreement with an appropriate institution for long-term security, monitoring and maintenance of the disposal site, including the establishment of a trust fund for financing these activities.

- Termination of SFC's NRC license under the restricted release provisions of 10 CFR 20.1403.

2.2 Disposal Cell Design

The principle feature of SFC's proposed decommissioning approach is the on-site, engineered disposal cell. SFC commissioned Morrison-Knudsen (M-K) to conduct a series of studies leading to the selection of a preferred location for the cell and a conceptual design and cost estimate for construction and closure of the on-site disposal cell. These included a siting study, a review of regulations pertaining to cell design features, and a conceptual design and cost estimate for the proposed cell. These studies are attached as appendices A through C.

2.2.1 Summary Description

Based on the M-K studies, a cell location in the existing Process Area was selected (see Figure 2-1).

The proposed cell is an above-grade unit built directly on prepared native soil or existing concrete pad areas without a base liner. Areas under the footprint of the cell that must be excavated for remediation purposes will be back-filled to the required base grade. The cell will be constructed by placement and compaction of the decommissioning wastes in pyramidal configuration with 5(H):1(V) sideslopes and 4 percent topslope. The completed cell will be capped with a clay layer of adequate thickness to control radon emissions and limit water intrusion, and covered with a drain layer and riprap to control erosion and limit bio-intrusion and human access (see Figure 2-2).

The conceptual design and cost contained in the M-K study is based on a cell sized to accommodate a total of 11,286,095 cf (418,000 cy) of contaminated materials (including a contingency of (4,100,000 cf)). The area of this cell footprint is approximately 20 acres. The base elevation will vary from about 555 ft. to 570 ft. above mean sea level (AMSL) with a top elevation of slightly over 600 ft. for the largest version.

The cell size for the options considered in this report will be adjusted proportionally by adjusting the height and footprint to accommodate the actual amount of decommissioning waste that is generated. For the proposed approach, the volume of the cell is estimated to be 5,122,340 cf (see Table 2.2-1) which would reduce the top elevation to about 590 ft. and the footprint to about 10 acres.

Following cell closure, performance testing will then be conducted to assure that the final cell design criteria for direct exposure, radon emissions and other critical parameters are met. Groundwater monitoring, as described in section 2.7 will also be initiated.

Table 2.2-1 Summary of Material Volume to be Placed in Disposal Cell

Material	Volume - cf[1]
Soils Outside Cell Footprint	434,000
Soils Under Cell Footprint	345,000
Buildings, Equipment, Structures and Concrete	1,080,455
Calcium Fluoride Sludge	625,280
CaF2 Basin Clay Liners	9,530
Raffinate Sludge	1,000,000
Scrap Metal	100,000
Pond 2 Residual	749,000
Solid Waste Burials	51,100
Pond 1 Spoils Pile	437,400
Interim Soils Storage Cell	140,950
Ponds 3E and 4 Clay Liner	22,000
Clarifier Clay Liners	33,000
Drummed Contaminated Trash	6,250
Empty Drums (crushed)	2,000
Sanitary Lagoon Sludge	10,365
Sanitary Lagoon Soil	5,640
Chipped Pallets (3,000)	10,000
Emergency Basin Sediment	14,600
Emergency Basin Soil	16,250
North Ditch Sediment	20,770
North Ditch Soil	8,750
Totals	5,122,340

[1] Volumes estimated for Proposed Decommissioning Approach.

2.2.2 Principle Disposal Cell Design Criteria

The principle design criteria for the disposal cell are:

- The cell cap will have a permeability of 1 X 10^{-7} cm/sec or less to limit the movement of water through the cell.

- The cell cap will be of sufficient thickness to limit radon flux to less than 20 pCi/m^2-s.

- Sludges shall be mixed with solidification agents (such as flyash) to develop an unconfined compressive strength sufficient to assure long-term resistance to sloughing or subsidence.

- The volume of voids and decomposable materials placed in the cell shall be limited to an average of 10% of the contained volume of the cell and shall not exceed 15% in any 2 foot layer.

- The cell cap will provide for prevention of intrusion by vegetation and burrowing animals, and deterrence of intrusion by humans through the use of a riprap cover.

- The design will limit erosion during a probable maximum precipitation event (PMP) of about 19 inches of rain per hour.

- The cell cap shall be designed to avoid effects on performance due to peak ground motions occurring from a maximum earthquake that could affect the site. The procedure provided in the "Technical Approach Document, Uranium Mill Tailings Remedial Action Project", U.S. Department of Energy, December 1989, or some other appropriate procedure, shall be used to determine maximum earthquake, peak ground motions, and slope stability..

2.3 Sludge and Sediment Treatment and Disposal

2.3.1 Description

Sludges (Raffinate and Calcium Fluoride (CaF_2)), sediments (Emergency Basin, North Ditch, and Sanitary Lagoon), and Pond 2 residue require treatment to improve their structural properties prior to being placed in the disposal cell. In addition, greater than 95% of the radium and thorium on the site is in these materials. Solidification will limit the mobility of these isotopes and will inhibit radon emissions.

SFC proposes to solidify this material with flyash and other additives to increase the compressive strength of the various materials to at least 50 PSI. A conceptual solidification system design, prepared by Earth Sciences for SFC, is proposed (see Appendix D for details). Solidification of these materials will also aid in retarding radon emissions and potential leaching of the other contaminants by rainwater percolating through the cell.

Two forms of treated material may be produced; one a slurriable grout for use as void filler and backfill for structural components, the other a soil-like material that is compacted into the cell. In either case, fly ash and, if necessary, portland cement will be added to yield a mixture that will have adequate compressive strength for cell stability. Data on the candidate fly ash is provided in Appendix E and data from a solidification feasibility study performed on the actual raffinate and calcium fluoride sludge is included in Appendix F.

Treatability tests on solidified sludges and soils and unsolidified soils are being conducted according to ANSI/ANS Standard 16.1-1986 to determine the leachability of the contained radionuclides. The data from these tests, which will be included in the Decommissioning Plan, will be used to determine the expected leach rates from the disposal cell for uranium, thorium - 230 and radium - 226.

2.3.2 Materials to be Treated

Raffinate Sludge

Raffinate sludge is currently stored in Clarifier Basins 1A, 2A, and 4A in Restricted Area 1. Approximately 1,000,000 cf (wet basis - 20% solids) contains an estimated 38.3 Ci U_{Nat}, 4.7 Ci Ra-226 and 145 Ci Th-230. This material also contains up to 150,000 kg of nitrate and 158,000 kg of fluoride. (See Appendix G for details.)

Calcium Fluoride Sludge

A total of 625,280 cf of calcium fluoride sludge containing an estimated 4.7 Ci U_{Nat}, 0.08 Ci of Ra-226 and 1.52 Ci of Th-230 is located in several basins and burial pits at the facility. This sludge is estimated to contain about 45% solids. (See Appendix G for details.)

Pond 2 Residue

This material consists of the original clay liner mixed with raffinate sludge that was formerly stored in the pond. There is about 749,000 cf of residue containing an estimated 10.8 Ci U_{Nat}, 1.6 Ci Ra-226, and 48 Ci of Th-230. (See Appendix G for details.)

Impoundment Sediments

This material consists of sediments in the Emergency Basin, the North Ditch, the Sanitary Lagoon, and possibly, a small portion of the clay liner material from the Clarifier Basins and Pond 4. A total of 45,735 cf of impacted sediment is contained in these areas with about 3.1 Ci U_{Nat}, 0.16 Ci Ra-226, and 5.3 Ci of Th-230. (See Appendix G for details.)

2.3.3 Material Handling and Treatment

As described more fully in Appendix D, the raffinate and calcium fluoride sludges will be transferred by slurry pump to feed tanks for blending and adjustment of the water content. This resulting mixture will be fed into a mixer where the fly ash and other additives are metered in. The slurriable mixture will then be pumped to the disposal cell area for placement as backfill around the components from equipment and building dismantlement.

The sediments, soils and/or sand materials will be excavated with backhoes, front-end loaders and scrapers, de-watered if necessary, placed in feed hoppers and conveyed to the mixer for blending with flyash and additives. The finished product will then be transported to the disposal cell with conveyors and/or dump trucks and compacted into place.

2.4 Structure and Equipment Dismantlement, Size Reduction and Decontamination

As part of the process to determine the size of the disposal cell, SFC performed an initial estimate of the anticipated disposal volume of the facility equipment and structural materials (after dismantlement and size reduction). This volume, as reported in a letter to the NRC dated October 4, 1996, was determined to be 1,080,455 cf. Uranium content was estimated at 16.4 Ci U_{Nat}.

A more detailed study was then conducted to refine the volume estimate and to develop conceptual plans, schedules and cost estimates for equipment and structure demolition (Appendix H). This study included a review of drawings and other data for the facility structures, equipment, utilities, and concrete in order to determine the location of radiological and chemical constituents, to understand the construction of the facility, and to facilitate planning of dismantlement methods. A disposal volume of 1,023,500 cf with 17.1 Ci U_{Nat} was determined.

All equipment and structures will be dismantled and size reduced, as necessary. All contaminated materials will be placed in the cell following cleaning, as necessary to recover economically recyclable uranium. The dismantled equipment and structural components will be entombed with the slurriable grout produced by the treatment of the sludges and other materials. Concrete and asphalt will be broken into manageable pieces and placed in the cell. Only limited decontamination of materials for unconditional release is planned.

2.5 Soil Remediation

Soils outside the footprint of the disposal cell which exceed the site-specific cleanup criteria described in Section 3 of this report will be excavated and placed in the disposal cell. This volume is estimated to be about 434,000 cf.

An additional estimated 952,000 cf of potential contaminated clay and soil lies beneath the ponds, basins and clarifiers. The fraction of this material exceeding the above criteria is expected to be small (< 10%). For purposes of this option, the volume to be remediated is assumed to be 95,200 cf.

A minimum of 1-foot depth from existing ground surface will be excavated in areas that indicate contamination levels higher than the site-specific cleanup criteria. The contaminated soils will be excavated and then underlying soils will be tested to ensure that soils with contamination levels above the site-specific cleanup criteria have been removed.

Soils within the footprint of the disposal cell with uranium concentrations in excess of 2500 pCiU/g will be excavated down to the soil/bedrock interface (average of about 15 feet). Most of this material, estimated at 345,000 cf, consists of the sand backfill under foundations and in utility trenches. Soils will not be excavated until the building slabs, foundations, utilities, and process lines have been removed.

Soils collected from prior cleanup activities that are presently located in the Interim Soil Storage Cell or in the Pond 1 Spoils Pile will also be removed and placed in the disposal cell. These materials have a volume of 578,000 cf.

Soils from excavation areas will be transported to stockpiles or to the disposal cell by haul trucks for longer distances and loaders for shorter distances. Existing roads will be used as much as possible; new haul roads will be constructed only as necessary.

Soils that do not require treatment will be placed into the cell in 10-12 inch lifts. Placement of this material will be sequenced with that of other materials to increase efficiency and stability, and to minimize settlement, voids, and leaching.

2.6 Other Materials

Scrap metal, drummed wastes, empty drums, used wooden pallets and other impacted materials that don't fall in the above categories will also be placed in the cell. Solid wastes which were buried on-site in the late 1970's and early 1980's will also be exhumed and placed in the cell. These materials are estimated to have a combined estimated volume of about 170,000 cf.

2.7 Groundwater Remediation

2.7.1 Background

SFC has defined four groundwater systems that underlie various portions of the facility. These are the Terrace Groundwater System, which is perched on the top of the site bedrock, the Shallow Bedrock Groundwater System, which includes all bedrock groundwater above Unit 4 Sandstone, the Deep Bedrock Groundwater System, which is immediately below Unit 4 Sandstone, and the Alluvial Groundwater System, which underlies the low grassland west of the fertilizer ponds and bordering the R.S. Kerr Reservoir.

The groundwater systems at the SFC site have been extensively investigated and characterized. The Facility Environmental Investigation Report and its Addendum, the Site Characterization Report and the RCRA Facility Investigation Report document these investigations. As determined by these investigations, the Terrace and Shallow Bedrock Groundwater Systems are impacted in various locations by one or more of the following constituents: uranium, arsenic, barium, nitrate and fluoride. The Deep Bedrock Groundwater System has not been not impacted by facility operation. The Alluvial Groundwater System is impacted by nitrates only.

2.7.2 General Approach and Rationale

SFC's proposed groundwater remediation approach is to remove and treat the more significantly uranium impacted Terrace Groundwater to minimize further impact to the Shallow Bedrock Groundwater and to rely on monitored natural attenuation for the remediation of the remaining uranium and/or chemical impacts in the Terrace, Shallow Bedrock and Alluvial Groundwater Systems. Based on assessments and modeling done to date (see Appendices K and L), SFC's determination that monitored natural attenuation will assure adequate protection of human health and the environment over the planning period specified in the regulations.

This determination is based on SFC's position that the drinking water pathway can be eliminated from dose and risk determinations. First, there are no existing drinking water wells near or down-gradient of the facility that could be impacted by migrating groundwater. The few active drinking water wells near the plant are either up-gradient from the facility or so far removed that future impact due to migration of contaminants is not possible.

Second, limited yield of groundwater wells is typical throughout this part of Oklahoma and has resulted in the construction of extensive potable water distribution systems that rely on surface water as their sources. The groundwater yields from the Terrace and Shallow Bedrock Groundwater Systems are consistent with other wells in the area of the facility. Water yields from monitoring wells in these zones are generally very low, many yielding less than the EPA minimum quantity of 150 gallons per day.

The exceptions to this are wells in areas affected by recharge from existing surface impoundments or man-made sub-surface reservoirs such as utility trenches and foundation backfill areas. Once these features are removed during decommissioning, the yields from the higher output wells are expected to decline.

The Alluvial Groundwater System has been found to have a high water yield. This groundwater system is primarily supplied by in-flow from the R.S. Kerr Reservoir. This water is therefore of relatively low quality (elevated dissolved solids and salinity), is not currently used for drinking water, nor could it be in the future without expensive treatment.

In summary, because of limited quantity or low quality, it is unlikely that viable drinking water wells could be established in the Shallow Bedrock Groundwater System. Additionally, SFC's planned permanent use restrictions and institutional controls are intended to prevent the construction of drinking water wells in the areas of long-term groundwater impact. These considerations provide a strong rationale for eliminating the drinking water pathway from site dose and risk determinations.

The primary environmental concern under the monitored natural attenuation alternative would be the potential affects of the migration of the contaminants into the R.S. Kerr Reservoir. The projected affects on the reservoir are discussed in Section 2.7.4 below.

2.7.3 Remediation of Terrace Groundwater

The primary uranium impacts in Terrace Groundwater System are located under the west end and off of the northwest and southwest corners of the Main Process Building, under and north of the SX Building, and on the west side of the Emergency Basin. Soil contamination is also present in these areas, both in the saturated and un-saturated zones, at levels that will require extensive excavation and removal. The Terrace Groundwater that is encountered during these excavations will be recovered and treated to remove uranium. The specific areas to be excavated will be mapped out in the SFC Decommissioning Plan. As indicated previously, SFC has recommended monitored natural attenuation of the chemical constituents to the responsible agencies.

2.7.4 Remediation of Bedrock Groundwater

SFC evaluated "monitored natural attenuation" (also referred to as "passive attenuation") as a bedrock groundwater remediation strategy for uranium impacts (See Appendix L). Based on the limited amount of groundwater available under the facility and the results of the groundwater fate and transport modeling for the Shallow Bedrock Groundwater System, natural attenuation of the uranium appears to provide sufficient protection to human health and the environment.

Uranium concentrations at selected observation points at the Process Area boundary peak at around 1000 years with concentrations in the 45 to 55 μgU/l range and then slowly taper off. Uranium concentrations at possible surface contact areas (i.e., seeps on the west side of the facility) are expected to be slightly lower due to additional dispersion and dilution that will occur as the uranium plume moves down-gradient and spreads horizontally. Arsenic is expected to behave similarly.

Appendix N provides an estimate of the rate that uranium and arsenic impacted groundwater might enter a surface seep or the river system. Resulting in-stream concentrations is then calculated using stream flow data published by the Oklahoma Water Resources Board. In-stream concentrations for uranium and arsenic were calculated using the highest concentrations from the fate and transport modeling presented in Appendix J and the highest groundwater flow rates established during site characterization. These concentrations were estimated to be 0.002 and 0.003 μg/l uranium and arsenic, respectively and 0.02 mg/l nitrate (N). A worst-case scenario for the un-named tributary west of the facility that might intercept the groundwater before it entered the Kerr Reservoir yields concentrations approximately 30 times higher, but still under levels of concern.

2.7.5 Remediation of Alluvial Groundwater

The nitrate present in the Alluvial Groundwater System originated from leaks from the Fertilizer Storage Ponds south of the Industrial Area. The groundwater modeling performed to date indicates that the nitrate will flush from the groundwater and into the R.S. Kerr Reservoir. Concentrations are predicted to drop below the current drinking water standard of 10 mg/l in about 200 years. In the interim, restrictions on the installation of drinking water wells in this groundwater system will be imposed. The maximum in-stream concentration of nitrate as (N) resulting from this plume is estimated to be 0.03 mg/l, well below the normal background level in this body of water. (See Appendix N.)

2.7.6 Conceptual Post-Remediation Groundwater Monitoring Plan

The conceptual post decommissioning groundwater monitoring program will be designed to confirm the predictions of uranium movement from the groundwater modeling. This monitoring program will consist of sampling wells in the Shallow Bedrock and Deep Bedrock Groundwater Systems. The Terrace Groundwater System will not be monitored since the remaining uranium impacted portions of this system will lie directly beneath the disposal cell. The monitoring program will use existing wells if they remain serviceable following decommissioning activities. All wells directly under the proposed foot print of the isolation cell (approximately 32 terrace system wells, 30 shallow bedrock system wells and 1 deep bedrock system well) will be plugged and abandoned in accordance with State and Federal guidance. The remaining wells will be left in place for future monitoring if necessary.

The conceptual post-remediation groundwater monitoring program will include the following wells:

- Five upgradient wells (two zones) - MW007A, MW007B, MW072A, MW072B, MW073A;
- Nine Industrial Control Boundary wells (one zone) - MW067A, MW049A, MW037A, MW040A, MW102A, MW065A, MW042A, MW066A, MW071A;
- Eleven perimeter boundary wells (two zones) - MW062A, MW062B, MW092A, MW095A, MW097A, MW098B, MW094A, MW099A, MW106, MW107, MW108;

Groundwater elevations will be collected each calendar quarter for two years following completion of decommissioning from all monitoring wells not affected by decommissioning activities. This will allow seasonal data to be gathered and provide time for the groundwater to stabilize after decommissioning activities have been completed. During the first five year period, sampling and analysis will be performed on a semi-annual basis. After five years, the frequency of monitoring activities will be determined from the previous monitoring results. Under existing conditions, groundwater monitoring would be conducted on an annual basis. Existing wells not affected by decommissioning activities and not selected for long term monitoring will be left in place for future sampling if plume conditions change.

The parameters that will be monitored include uranium, fluoride, nitrate and arsenic.

2.8 Site Restoration

Excavated areas, including the existing basins and impoundments, will be backfilled with on-site rock and soil, including the material in the impoundment dikes that meets the leave-in-place criteria. These areas will be graded with a slight slope to provide adequate drainage of stormwater. A 6-inch layer of top soil will then be applied and seeded with grass to limit erosion.

2.9 Wastewater Management

A wastewater management system will be employed during decommissioning for the collection, storage and treatment of wastewater. Wastewater includes stormwater, process water and recovered groundwater from the decommissioning and decontamination process, which may include wastewater from soil washing, equipment washing, sludge de-watering, temporary storage area runoff, and dust suppression.

To the extent possible, the wastewater management system will employ existing facilities and basins for the storage and treatment of wastewater, and for the post-treatment storage of treated wastewater. The proposed system would involve batch treatment of accumulated water in the 3A Clarifier to precipitate out uranium, thorium and radium. A combination of settling and filtration would then be used to remove the precipitated metals. Activated alumina and ion exchange resin may be used to remove arsenic and residual radionuclides if necessary. Since this waste water will most likely be impacted by nitrates, the treated water would then be land applied on the Ag-Land fields as fertilizer.

2.10 Long-Term Site Control

Once the decommissioning is completed and SFC's NRC license is terminated, SFC will turn the disposal cell and the permanently restricted property over to an entity such as the Department of Energy for long-term control. A trust fund will be established to cover the anticipated cost of controlling the site as described below.

An Institutional Control Boundary (ICB) approximating the current Restricted Area 1, will be established as a permanent restricted-use zone. It will be fenced to deter access by unauthorized persons and large animals. Security guards or surveillance inspections beyond those that would occur as a result of performing the planned maintenance and groundwater sampling are not considered necessary.

Approximately six times per year, the grass will be cut and any other required maintenance performed. The groundwater monitoring program described in section 2.7 will also be conducted as part of this activity.

2.11 Cost of Proposed Approach

The costs associated with SFC's proposed decommissioning approach, as presented in Table 2.11-1, only reflect the "direct costs" for performing the various decommissioning activities. Likewise, cost estimates for the alternatives also only consider "direct costs". General and Administrative costs such as SFC staff salaries and overhead, license and permit fees, taxes, routine environmental monitoring costs, etc., are assumed to be the same for all alternatives and are therefore not included in these estimates.

Costs that are included as "direct costs" include those associated with engineering, design and construction; excavation and handling of material; backfilling excavated areas; deconstruction of buildings, structures, and equipment; sludge and sediment treatment; cell filling; cell closure; wastewater handling and treatment; monitoring during remediation; and post-remediation monitoring, maintenance and security.

Table 2.11-1 ESTIMATED DIRECT COSTS FOR PROPOSED DECOMMISSIONING APPROACH

Activity	Direct Cost ($.000)	Notes
1. Contractor mobilization/ demobilization	650	Appendix D, Section 6.2
2. Sludge, Sediment Solidification	4,357	2,765,530 cf of sludges etc. to be excavated, treated and placed in the disposal cell at a cost of $1.80/cf.
3. Disposal Cell Construction/Closure	3,850	Based on M-K cost estimate contained in Appendix C for an 11,286,000 cf cell with a 20 acre footprint.
4. Soil Remediation	923	Appendix I, Table 10-1, Item 200 Total adjusted for remediation of 434,000 cf of soil outside the footprint of the cell excavated (>162 μgU/g) and 345,000 cf of backfill sand/contaminated soil inside the footprint excavated at $0.48/cf (includes cost of cell placement). Unit cost is from Table 10-1 of M-K Report in Appendix I.
5. Building and Equip. Deconstruction	4,700	B&W base cost estimate plus 25%, Appendix H, page H-6.
6. Ground Water Remediation	150	In the proposed approach, ,the significantly impacted Terrace Groundwater will be recovered and treated during soil excavation and structure dismantlement. Treatment costs are covered in the Wastewater Management Cost Line. Monitored natural attenuation for long-term remediation of the remaining Terrace and Shallow Bedrock Groundwater impact, involving monitoring only, is assumed. Monitoring costs are included in the Long-Term site Control Cost line and the Post-Closure Monitoring Line.
7. Site Restoration	2,226	Cost to backfill, place topsoil and re-vegetate excavations and other affected areas. Based on filling in 1,468,000 cf of excavations and dozing approximately 17,500,000 cf of dike material into impoundments at $0.084 per cf, applying 6 inches of topsoil to 83 acres (1,807,740 cf at $0.33/cf) and seeding 83 acres at $441/acre.
8. Waste Water Management	500	Estimated cost to install pumps, sand filters and ion exchange beds for polishing of treated water.
9. EIS Support	1,600	Estimated NRC fees for preparing EIS.
10. Additional Site Characterization	500	SFC estimate to complete.

Table 2.11-1 ESTIMATED DIRECT COSTS FOR PROPOSED DECOMMISSIONING APPROACH

Activity	Direct Cost ($,000)	Notes
11. Long-Term Site Control	1,062	Assumes an escrow fund at 2% interest to generate funds for the annual long-term maintenance costs of $21,244. Costs include annual sampling of 25 monitoring wells and analysis for uranium, nitrate and arsenic, preparation of an annual report, NRC inspection fees, mowing 6 times per year, and $500 annually for general maintenance. <u>Sampling Costs</u> Well Purging 16 hours @ 35.00 = 560.00 Well Sampling 16 hours @ 35.00 = 560.00 $ 1,120.00 <u>Analytical Costs</u> Uranium $20.00 Nitrate $15.00 Arsenic $25.00 Prep Fee $20.00 Total $80.00 per well x 25 wells = $ 2,000.00 <u>Annual Report</u> 80 hours @ $90 7,200 Copying Costs 200 = $ 7,400.00 <u>NRC Inspection Fees</u> Travel Time 8 hours Inspection Time 4 hours Report Preparation 40 hours Total 52 hours @ $132.00 = $ 6,864.00 <u>Mowing</u> 16 hours per mowing x 6 mowings per year = $ 3,360.00 <u>General Maintenance</u> $500.00 per year = $ 500.00 Total $21,244.00
12. Post-Closure Monitoring Program	20	Post-closure monitoring includes the costs for purging, sampling and analysis for 25 wells for an additional sampling event for the first five years after cell closure.
13. Engineering/construction management	2,506	15% of lines 2 through 8.
Total	23,044	

3.0 Evaluation of Site Specific Cleanup Criteria

Absent a regulation specifying an acceptable level of residual radioactivity in soil for termination of a license or definitive guidance for selection of such, SFC was constrained to develop site specific criteria. To do so, SFC estimated possible human health and ecological risks associated with the site based on a variety of information including site characterization data, fate and transport of contaminants, possible receptors, and types of potential exposures. Specifically, SFC used the RESRAD computer model (ANL 1989), standards from Appendix A of 10 CFR 40 and a DOE order, EPA default values presented in Region IX's Preliminary Remediation Goals (PRGs) (EPA 1992), and professional judgement. Collectively, these and other sources provide the basis for the cleanup criteria.

3.1 Identification of COCs

COCs are the constituents detected at the Facility that have the potential to pose a hazard to humans or the environment and are evaluated in the selection of site-specific cleanup criteria.

Based on historical information including findings of site investigations, the potential radiological COCs for soil, surface water, sediment and groundwater were determined by SFC to be natural uranium and associated decay products, and thorium-230 and radium-226.

The potential chemical COCs identified for the Facility by SFC in previous investigations are arsenic, fluoride, and nitrate.

3.2 Pathway Analysis/Transport Modeling

The primary potential exposure pathways relative to the COCs were evaluated individually as part of the development of cleanup criteria. These primary pathways included groundwater, surface water, air, and soil. As stated in Section 2.7 of this report, it is assumed that groundwater is not a credible exposure pathway.

Surface water and air have been extensively monitored during the life of the Facility. In each case, the COC levels in these media have been within regulatory limits. Inherent in the overall design, these media will not be subject to impacts upon completion of the decommissioning process. Therefore, it is assumed that surface water and air are not feasible exposure pathways.

Soil has also been extensively monitored and investigated at the Facility. Impacts from COCs do exist in the soils at the Facility. There are several pathways involving soil which could manifest exposure of potential receptors to the COCs present in soil. The greatest potential for exposure of a receptor would be a scenario involving an individual living on the site, after decommissioning is complete, and a substantial fraction of the individuals food being provided from the residence.

The pathways included for assessment of the radiological cleanup levels were: external radiation; inhalation of particulates; inhalation of radon; ingestion of plant, meat, and milk provided from the residence; and incidental ingestion of soil. The exposure pathways included for assessment of the non-radiological cleanup criteria were: inhalation of particulates, incidental ingestion of soil, and dermal contact with soil.

An exposure scenario involving an industrial worker providing periodic maintenance of the site after decommissioning is complete was also evaluated. The exposure pathways included were: external radiation from soils; inhalation of particulates, inhalation of radon, incidental ingestion of soil, and dermal contact with soil (non-radiological only).

No exposure pathways were considered for the resident farmer or industrial worker with regard to the disposal cell. The design of the cell will inherently address the relevant exposure issues.

3.3 Site Specific Cleanup Criteria

Cleanup criteria were developed by addressing the two main factors used to evaluate appropriate cleanup options for a site: (1) long-term protection of human health and the environment as indicated by site-specific risk assessments, and (2) compliance with environmental requirements. Standards and guidelines are available for some of the COCs at the SFC Facility, but not for all. Thus, two types of criteria are provided for the decommissioning of the Sequoyah Facility, generic and derived. Generic criteria from generally applicable standards and guidelines were used where available. In the absence of generic criteria, appropriate cleanup levels were derived by site-specific assessments.

3.3.1 Radiological

Generic criteria were chosen for each of Ra-226 and Th-230. The cleanup criteria for Ra-226 were adopted from EPA standards. The EPA has promulgated standards for Ra-226 in soil at uranium mill tailings sites (40 CFR 192). The NRC has provided the same criteria in Appendix A of 10 CFR 40. Although SFC is not a mill tailings site, these standards are appropriate. Namely, the soils at SFC are similar to those at a mill tailings site and, more importantly, the radiation protection issues (direct exposure and exposure to radon daughters) are the same.

The DOE has established guidelines for Th-230 in soil in areas of unrestricted access. These guidelines were adopted here as cleanup criteria from DOE Order 5400.5 and were included to protect from future exposures to Ra-226 as a result of radionuclide ingrowth.

For natural uranium in soil, no generic criteria are available. Therefore the cleanup criteria chosen here were derived based on regulatory precedent and site specific information. The NRC has identified 25 mrem per year as an annual dose limit to the whole body for exposures associated with management of uranium byproduct materials; e.g. 40 CFR 190 and 40 CFR 192, and Appendix A of 10 CFR 40, respectively. Hence, the cleanup criteria was chosen to provide reasonable assurance that a total effective dose equivalent of 25 mrem per year to any individual member of the public will not be exceeded as a result of exposure to residual uranium, radon and its daughters included. Using the RESRAD computer code, a uranium concentration in soil was derived to satisfy this dose limit. The concentration determined by RESRAD at the 25 mrem/y to the resident farmer was about 162 μg/g (110 pCi/g) natural uranium.

An ALARA assessment was made of the relationship between soil volume requiring excavation and the uranium concentration in soil. Volumes of soil requiring remediation were estimated for uranium concentrations of 40, 200, 325, and 1300 μg/g. These volume estimates and concentrations were graphed to determine where the value of soil removal becomes less effective; i.e. the point of diminishing return. The optimum concentration would be chosen at a point where the volume requiring remediation begins to increase dramatically without significant reduction in uranium concentration. (Note that this methodology could analogously be applied with respect to dose and the same conclusion would be reached.) The optimum concentration appears to be in range of 100 to 300 μg/g as shown in Figure 3-1.

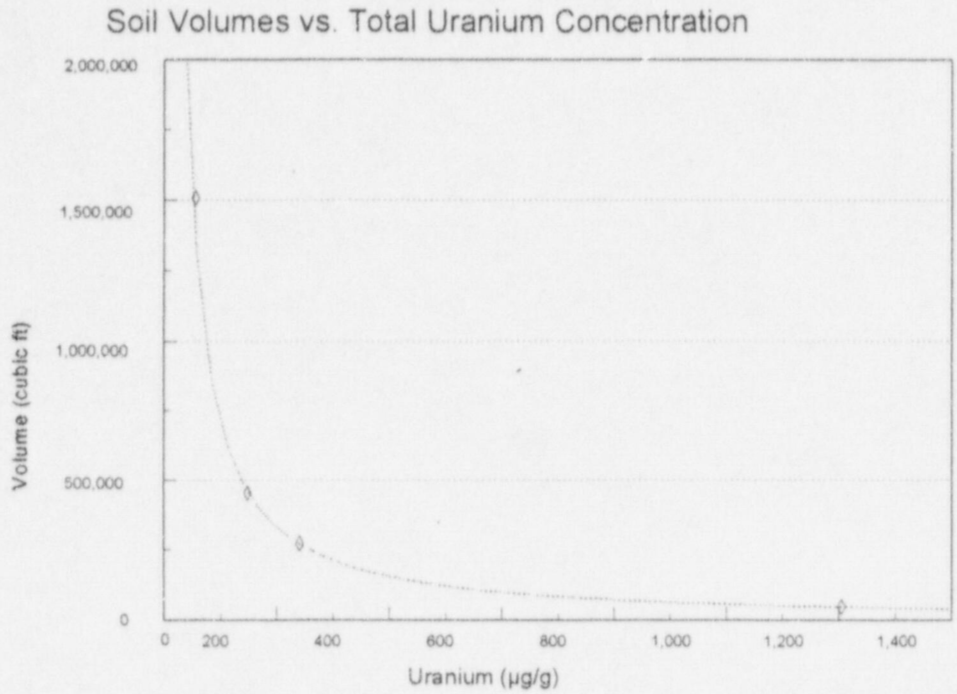

Figure 3-1

The radiological cleanup criteria were established conservatively enough such that the combined impact would not exceed a maximum acceptable dose which was chosen to be equivalent to 100 mrem per year total effective dose equivalent. Under normal circumstances, the actual dose would be a fraction of 100 mrem per year. This methodology uses an established public dose limit of 100 mrem per year as a threshold for determining if the site poses a significant risk to the public. Such an approach is consistent with existing NRC standards and guidance; e.g. 10 CFR 20, NRC Branch Technical Position on screening methodology for former burial sites, and NRC NUREG-1500 draft regulatory guide on release criteria for decommissioning.

Finally, comparable criteria have been applied in similar manner by DOE and EPA at a former uranium conversion facility near Weldon Spring, Missouri. At Weldon Spring, a site specific criteria was derived for uranium in soil and the generic criteria described above were applied for thorium and radium. These criteria were chosen based on a resident farmer scenario and compared to a basic dose limit of 25 mrem per year from uranium and generic protection from thorium and radium.

Cleanup criteria for radiological COCs are presented in Table 3.3-1.

Table 3.3-1 Site Specific Radiological Cleanup Criteria

COC	Surface[1] (0 to 15 cm)	Subsurface[1] (below 15 cm)
Uranium (Natural)	162 μg/g (110 pCi/g)	162 μg/g (110 pCi/g)
Thorium	5 pCi/g	15 pCi/g
Radium	5 pCi/g	15 pCi/g

1 These criteria apply independently as concentrations in soil above background, averaged over an area of 100 m^2. Concentrations are averaged over the first 15 cm below the surface, and averaged over 15 cm thick layers more than 15 cm below the surface.

3.3.2 Non-Radiological

Arsenic, nitrate and fluoride are the non-radiological COCs that may be present in the soil from previous Facility operations. It is expected that direct contact with soil via inadvertent ingestion, dermal contact and inhalation of particles from soil are the most likely routes of exposure of the COCs. Oklahoma Department of Environmental Quality (ODEQ) or EPA PRGs are proposed for the non-radiological cleanup criteria for both the residential and industrial worker scenarios. The cleanup criteria based upon the industrial worker scenario is intended for use within the institutional control boundary surrounding the disposal cell.

ODEQ's generic risk-based guidelines were given priority when selecting cleanup criteria. When an ODEQ value was not available, the Region IX PRGs were selected as cleanup criteria for the SFC Facility.

ODEQ provides cleanup levels for arsenic, but not for nitrate or fluoride. Region IX PRGs are based on default EPA exposure factors (OSWER Directive, 9285.6-03) and supplemented with more recent information from EPA's Solid Waste and Emergency Response, EPA's Office of Research and Development, and California EPA's Department of Toxic Substances Control. They are based on three routes of exposure to soil; ingestion, dermal contact and inhalation of soil. The residential scenario soil PRGs consider ingestion, dermal contact and inhalation rates for a combined adult and children exposure for the carcinogenic chemical constituents. Use of the age-adjusted factors are especially important for soil ingestion exposures, which are higher during childhood and decrease with age. Age-adjusted factors are also conservatively used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30 combining contact rates, body weights and exposure durations for two age groups (i.e., small children and adults).

Cleanup criteria for non-radiological COCs are presented in Table 3.3-2.

Table 3.3-2 Site Specific Non-Radiological Cleanup Criteria

COC	Industrial Scenario	Residential Scenario
Arsenic[1] (mg/kg)	50	20
Fluoride (mg/kg)	41,000	880
Nitrate (mg/kg)	100,000	10,500

[1] Arsenic remediation is addressed under the EPA-SFC AOC dated 08/03/93.

4.0 Alternatives Considered

This section describes several alternatives which were considered for the decommissioning of the facility. A brief description of the differences between the Proposed Approach and each of the other alternatives is provided. Incremental cost differences compared to the Proposed Approach and a total direct cost estimate is given in each case.

4.1 ALTERNATIVE 1: Addition of Terrace and Shallow Bedrock Groundwater Remediation

4.1.1 Description

This alternative was developed to establish conceptual designs and cost estimates for the remediation of the Terrace and Shallow Bedrock Groundwater that is impacted by uranium and arsenic. If groundwater remediation is determined to be necessary, these costs are to be added to those for the alternative selected (i.e., the Preferred Alternative or Alternatives 2 through 7). The conceptual design for these alternatives are presented in Appendix M.

4.1.2 Costs

Incremental costs for this option would include the costs of detailed design, construction, operation and maintenance of groundwater recovery and treatment systems for an extended period of time following completion of the site decommissioning. Two approaches have been evaluated, Alternatives 1A and 1B.

Capital costs for 1A are estimated to be $3,450,988 and annual operating and maintenance costs to be $223,285. The escrow account increment to cover these O&M costs would be $11,164,250 for a total cost for alternative 1A of $14,615,238. See Appendix M for details on these cost estimates

Capital costs for 1B are estimated to be $2,660,686 and annual operating and maintenance costs to be $289,083. The escrow account increment to cover these O&M costs would be $14,454,150 for a total cost for alternative 1A of $17,114,836. See Appendix M for details on these cost estimates.

4.2 ALTERNATIVE 2: On-site Disposal With Remediation of All Soils Greater Than 40 μgU/g

4.2.1 Description

This option is the same as Proposed Approach except that all soils and bedrock which exceed the current Facility Action Level of 40 μgU/g will be excavated and placed in the disposal cell. Excavations will be backfilled to the original grade with clean fill, covered with topsoil and re-vegetated.

4.2.2 Costs

Incremental costs for this option include the cost of additional manpower and equipment for the excavation of the additional soils under the footprint of the cell which exceed 40 μgU/g. Costs would also be incurred for the excavation and placement of clean backfill material, and for the handling and placement of the additional material into the disposal cell. The incremental volume of soil/bedrock that would require excavation is estimated to be 3,643,000 cf. At an average unit cost of $0.61/cf (Appendix I, Table 10-1), the incremental cost of excavation and placement in the cell would be $2,222,000. The incremental cost to backfill and grade the resulting excavations, at a unit cost of $0.64/cf (Appendix I, Table 10-1) would be $2,332,000. Costs for application of topsoil and re-vegetation are included in Proposed Approach. The total cost of this option, as shown in Table 4-1, would be $28,231,000.

Table 4-1 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 2

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	4,357
3. Disposal Cell Construction/Closure	3,850
4. Soil Remediation	3,145
5. Building and Equipment Deconstruction	4,700
6. Ground Water Remediation	150
7. Site Restoration	4,558
8. Waste Water Management	500
9. EIS Support	1,600
10. Additional Site Characterization	500
11. Long-Term Site Control	1,062
12. Post-Closure Monitoring Program	20
13. Engineering/construction management	3,189
Total	28,281

4.3 ALTERNATIVE 3: On-site Disposal With Solidification of All Soils Greater Than 40 µgU/g (Monolith Design)

4.3.1 Description

This option is the same as the ALTERNATIVE 2 except that all excavated soils would also be solidified per Earth Science's solidification system conceptual design. Slurriable grout will be produced as required and used as void filler and backfill material around all building debris, equipment and other solid materials to construct a monolithic structure that would contain all the decommissioning wastes. Soil-like materials will be produced from remaining soils and compacted around the "slurry and solids lifts" to complete the monolith.

4.3.2 Costs

Incremental costs for this option include the manpower and equipment for excavation, handling, solidification and placement of the additional 3,643,000 cf of soil into the cell. At an average density of 100 pounds/cf and an estimated processing cost of $85/ton (Appendix D, Section 6-4), the incremental handling cost would be $15,483,000. Incremental costs will also include backfilling of the excavated areas at $2,332,000. Total cost for this option, as shown in Table 4-2 would be $43,629,000.

Table 4-2 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 3

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	4,357
3. Disposal Cell Construction/Closure	3,850
4. Soil Remediation	16,406
5. Building and Equipment Deconstruction	4,700
6. Ground Water Remediation	150
7. Site Restoration	4,558
8. Waste Water Management	500
9. EIS Support	1,600
10. Additional Site Characterization	500
11. Long-Term Site Control	1,062
12. Post-Closure Monitoring Program	20
13. Engineering/construction management	5,276
Total	43,629

4.4 ALTERNATIVE 4: On-site Retrievable Storage

4.4.1 Description

On-site disposal in an above grade design of the cell represents a "retrievable" option with the exception of the solidified materials in that the cover could be removed and the materials loaded into shipping containers with the same type of construction equipment used to place the materials in the cell. It is not anticipated that contamination spread or excessive worker exposure would result from this retrieval activity.

This option is a variation of ALTERNATIVE 2, in which all soils >40 μg/g are remediated. To allow "retrievability" of the solidified materials, the slurry product would be cast into movable blocks using 13.5 cf "Supersacks". The sacks, which have integral lifting straps, would then be stacked in the disposal cell. Metal components (piping, equipment, structural steel, etc.) will be size reduced, placed in the disposal cell, and backfilled with compacted soil.

4.4.2 Costs

Incremental costs for this option include the purchase costs of the "Supersacks", and costs for casting the sludges, sediments and soils into the sacks, and placing the sacks in the cell. Anticipating a 20% increase in volume of the solidified material, about 3,000,000 cf of material would have to be sacked. This requires 222,000 sacks at approximately $20 per sack at a cost of $4,440,000. Handling costs are estimated to be about 50% over the $4,357,000 solidification cost projected in OPTION 3, or $2,179,000. Total cost of this option, as shown in Table 4-3, would be $35,892,000.

Table 4-3 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 4

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	10,976
3. Disposal Cell Construction/Closure	3,850
4. Soil Remediation	3,145
5. Building and Equipment Deconstruction	4,700
6. Ground Water Remediation	150
7. Site Restoration	4,558
8. Waste Water Management	500
9. EIS Support	1,600
10. Additional Site Characterization	500
11. Long-Term Site Control	1,062
12. Post-Closure Monitoring Program	20
13. Engineering/construction management	4,181
Total	35,892

4.5 ALTERNATIVE 5: Off-site Disposal of Solidified Sludges, Sediments and Residues

4.5.1 Description

This option is similar to ALTERNATIVE 4 except that solidified and "Supersacked" sludges (raffinate and calcium fluoride), sediments (Emergency Basin, North Ditch, and Sanitary Lagoon) and Pond 2 residue would be shipped off-site for disposal.

4.5.2 Costs

The incremental costs for this option cover the costs projected in OPTION 5 would be the shipping and disposal fees for off-site disposal. 3,000,000 cf of solidified material at 110 pounds/cf will weigh about 150,000 tons. At 20 tons per truckload, this represents 7,500 loads. The shipping cost to the Envirocare site in Utah would be approximately $3,500 per load for a total shipping cost of $26,250,000. Disposal fees are estimated to be $45,000,000 (at $15/cf, estimate based on informal discussions with Envirocare). Total cost for this option, as shown in Table 4-4 is $107,142,000.

Table 4-4 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 5

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	10,976
3. Disposal Cell Construction/Closure	3,850
4. Soil Remediation	3,145
5. Building and Equipment Deconstruction	4,700
6. Ground Water Remediation	150
7. Site Restoration	4,558
8. Waste Water Management	500
9. EIS Support	1,600
10. Additional Site Characterization	500
11. Long-Term Site Control	1,062
12. Post-Closure Monitoring Program	20
13. Engineering/construction management	4,181
14. Shipping	26,250
15. Disposal Fee	45,000
Total	107,142

Note: Use of rail shipping could reduce the shipping cost by about $10,000,000 (40% reduction), however a rail spur and loading system would have to be installed. A rough estimate of this cost is about $3,000,000 for a net reduction of about $7,000,000.

4.6 ALTERNATIVE 6: Off-site Disposal of De-Watered Sludges, Sediments and Residues

'.6.1 Description

This option is similar to ALTERNATIVE 5 except that sludges would be "de-watered" rather than solidified. The feasibility of de-watering the raffinate sludge is questionable, however, assuming a satisfactory method could be developed, the volume to be disposed of could be reduced to about 1,700,000 cf or about 93,500 tons.

4.6.2 Costs

De-watering costs would be expected to be roughly the same as the cost to solidify that material. Cost for Supersacks for this option would be $2,520,000 (126,000 sacks at $20). Truck shipping would be $16,360,000 (4675 loads at $3,550 per load) and Envirocare disposal would be $25,500,000 ($15 per cf, estimate based on informal discussion with Envirocare). Total :ost for this option, as shown in Table 4-5, would be $75,543,000.

Table 4-5 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 6

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	9,055
3. Disposal Cell Construction/Closure	3,850
4. Soil Remediation	3,145
5. Building and Equipment Deconstruction	4,700
6. Ground Water Remediation	150
7. Site Restoration	4,558
8. Waste Water Management	500
9. EIS Support	1,600
10. Additional Site Characterization	500
11. Long-Term Site Control	1,062
12. Post-Closure Monitoring Program	20
13. Engineering/construction management	3,893
14. Shipping	16,360
15. Disposal Fee	25,500
Total	75,543

4.7 ALTERNATIVE 7: Off-site Disposal of All Contaminated Materials

4.7.1 Description

Under this option, all the decommissioning waste materials would be shipped off-site for disposal. It is assumed that soils above the 40 μgU/g would be excavated and shipped along with de-watered sludges and dismantled structures and equipment. Excavation would be backfilled, topsoil placed and the site re-vegetated. Up to 9,000,000 cf of material averaging about 110 pounds/cf would be involved.

Upon completion, the site would be released for unrestricted use except for groundwater. Permanent deed restrictions prohibiting the installation of wells in the areas impacted by uranium or arsenic would be put in place. The groundwater at and west of the existing fertilizer ponds would be restricted to use to irrigation only until such time as the nitrate levels were reduced to less than drinking water standards by the natural processes.

4.7.2 Costs

Total cost for this option would be $174,385,000 as shown below in Table 4-6. The cost of this option represents elimination of costs for a disposal cell and long term site control, and the addition of costs for post-closure groundwatering ($10,600/yr), rail shipping ($54,975) and a disposal fee of $10/cf.

Table 4-6 ESTIMATED DIRECT COSTS FOR ALTERNATIVE 7

Activity	($,000)
1. Contractor mobilization/demobilization	650
2. Sludge, Sediment Solidification	9,055
3. Soil Remediation	3,145
4. Building and Equipment Deconstruction	4,700
5. Ground Water Remediation	150
6. Site Restoration	4,711
7. Waste Water Management	500
8. EIS Support	1,600
9. Additional Site Characterization	500
11. Long-Term Site Control	0
12. Post-Closure Monitoring Program	1,060
13. Engineering/construction management	3,339
14. Shipping	54,975 [1]
15. Disposal Fee	90,000
Total	174,385

[1] Assumes rail shipping

4.8 No Action

The results of the No Action risk assessment indicate that the potential human health impacts associated with a resident farmer exposure at the SFC site are not acceptable when compared with NRC and EPA guidelines, indicating the need for further assessment or decommissioning activities. On the basis of the assumptions used in the risk evaluation, exposure to COCs at the site exceed the target risk levels for carcinogenic and non-carcinogenic effects by a significant amount (see Appendix K).

5.0 Affected Environment

5.1 Land and Water Use

5.1.1 Land Use

The SFC site is on gently rolling to level land of which two-thirds is forested and one-third is open field. Elevations on or near the site range from 460 feet above mean sea level for the normal pool elevation of the Robert S. Kerr Reservoir to 570 feet. Slopes over most of the upland areas of the site are less than 7%. Steeper slopes of creek ravines and hillsides average roughly 28%. The process area is located on land 570 feet in elevation. Approximately 600 acres are occupied by the Facility. Most of the pasture land (i.e. approximately 200 acres) surrounding the 200 acre Industrial Area is used for forage production in conjunction with the SFC fertilizer application program.

Prior to the advent of railroads in the area, the land was used primarily as cattle range. With availability of railroads, corn and cotton became the main agricultural products. In the last 30 years, however, the trend has been away from cultivation of these crops and back to cattle grazing and the production of other food crops. Areas remaining in cultivation are primarily in the bottom lands along the Arkansas River. In 1970, about 30% of the acreage of Sequoyah County was used for range and about 40% was forested. The range is usually grazed year around, but the forage is supplemented with protein cubes, prepared pasture, and hay consisting of tame grasses and small grain. High-quality trees have been largely eliminated from the forested areas by heavy cutting, fires, and uncontrolled grazing. Most woodland in the county is used for grazing.

Within a 10 mile radius of the SFC Facility, the following uses have been estimated:

Land Use	Percent[a]
Agricultural (mostly pasture)	30
Recreation	35
Residential	20
Commercial & Industrial	15
Unused Rough Terrain	25

[a] Due to multiple use of some areas, the total exceeds 100%.

The large acreage for recreation is represented primarily by the federally-owned land and water areas along the Arkansas and Illinois Rivers and includes the

21,000 acre Sequoyah National Wildlife Refuge, where large numbers of migrating waterfowl are found in the spring, fall and winter.

5.1.2 Water Use

An area-wide water well survey conducted by SFC and the Oklahoma State Department of Health during 1990-91 documents that no impacts from Sequoyah Facility operations have occurred on area water wells. Most of the water wells identified in the off-site well survey are not in current use, and there are no groundwater users noted downgradient of the Sequoyah Facility process area. The Sequoyah County Rural Water Association now supplies rural water to area residents.

The only significant fresh water aquifer in the immediate site area is the alluvium of the Arkansas River Valley. The lower part of the alluvium consists of up to 15 feet of coarse sand with a productivity of as much as 900 gpm. The water is classified as "hard to very hard" (greater than 180 mg/l total hardness) but is suitable for irrigation and watering stock.

The hydrologic conditions in the immediate areas of the Sequoyah Facility are typical of those for the Atoka formation. This formation is considered to be a very poor aquifer because the soil cover is thin and has poor permeability, and the underlying sandstone and shale beds require fracturing to provide storage capacity. Water quality is poor and yields average only 0.5 gpm. It is estimated that because of the very low permeability of the Atoka rocks, approximately 95% of the rainfall is lost by surface runoff.

The SFC facility does not use groundwater resources, but obtains raw water from the Tenkiller Reservoir located about 7 miles to the north. Potable water is obtained from the Sequoyah County Rural Water Association.

5.2 Community Resources

5.2.1 Socioeconomic Characteristics

5.2.1.1 Population

The SFC site, situated in rural, western Sequoyah County (see Figure 5-1), which had a 1990 population of 33,828. The four (4) adjacent counties of Muskogee, Haskell, McIntosh and Cherokee had a combined 1990 population of about 129,846. The major population center is the city of Muskogee (37,708), about 25 miles to the northwest. Nearby towns include Gore (690), Webbers Falls (722), Warner (1,479), Vian (1,414), Checotah (3,290) and Sallisaw (7,122), all of which are located along Interstate 40 or old U.S. Route 64. The total population within 5 miles of the site is about 3,103.

Because the area is rural, there is not a large residential population nearby, and no sensitive populations have been identified in the vicinity of the SFC site.

5.2.1.2 Housing

Housing data for Gore, Webbers Falls, Vian, Sallisaw, and Muskogee, and data for Sequoyah and Muskogee counties are summarized in Table 5.2-1. There are 1,979 vacant housing units in Sequoyah County, and 3,708 vacant housing units in Muskogee County. (1990 Census information, Book CPH-1-38)

Table 5.2-1. 1990 Housing in Sequoyah and Muskogee Counties

Place	Total Units	Vacant units	Homeowner vacancy rates (%)	Rental vacancy rates (%)	Median value ($)	Median contract rent ($)
Sequoyah County	14,314	1,979	2.5	12.1	37,800	196
Gore	304	38	4.3	10.7	41,700	183
Vian	590	96	3.3	15.3	30,100	142
Sallisaw	3,108	265	2.8	9.0	39,600	219
Muskogee County	28,882	3,708	3.7	15.1	40,900	217
Webbers Falls	334	59	2.2	8.2	19,800	147
Muskogee	17,663	2,585	5.4	16.1	40,300	229

Source: U.S. Bureau of the Census 1990.

5.2.1.3 Public Infrastructure

There are seven (7) school districts in Sequoyah county, which operate a total of 14 elementary schools, three (3) middle schools, one (1) junior high school and seven (7) high schools. Total enrollment in the 1993-1994 school year was 7,822. Muskogee County has ten (10) school districts with a total enrollment of 13,558.

The only acute care medical facility in Sequoyah County is Sequoyah County Memorial Hospital located in Sallisaw, Oklahoma. The hospital has 50 beds.

Fourteen physicians are in active practice in the county (Statistical Abstract of Oklahoma - 1993).

Water for the town of Gore is supplied by the Gore Public Works Authority, which processes water from Lake Tenkiller. Webbers Falls water is provided by the East Central Oklahoma Water Authority, which receives water from the Gore Public Works Authority. The city of Sallisaw has it's own water system, and receives and processes water from Brushy Lake. Most of the rural community receives water from Rural Water Districts.

Oklahoma Gas and Electric Company (OG&E) provides electricity to the Sequoyah Facility, as well as much of the surrounding towns, including Muskogee, Gore, Webbers Falls and Vian. The city of Sallisaw is supplied by the Grand River Dam Authority. Much of the rural community is supplied by Rural Electric Cooperatives.

Gas services for the town of Gore is provided by East Central Oklahoma Gas Authority. The towns of Muskogee, Webbers Falls and Vian are supplied by Oklahoma Natural Gas. The town of Sallisaw is supplied by Arkansas Oklahoma Gas Corporation. Most rural areas use propane.

The regional transportation system in the SFC area is dominated by Interstate 40 (carrying traffic east/west). State Highway 10 carries traffic north/south in the immediate vicinity of the site. State Highway 151 (Muskogee Turnpike) is the primary link between Tulsa, Oklahoma and Fort Smith, Arkansas, and joins Interstate 40 about five miles west of the Sequoyah Facility. Average daily traffic counts on the road segments near the Sequoyah Facility are provided in Table 5.2-2.

Table 5.2-2 Average daily traffic on major roads near the Sequoyah Fuels Corporation Site

Road Segment	Total Daily Traffic			Date
I-40 at Arkansas River Bridge	Eastbound Westbound	- -	7,214 7,584	2/96 2/96
I-40 East of Highway 10	Eastbound Westbound	- -	8,588 7,716	2/96 2/96
Highway 10 North of I-40			576 1,321*	2/96 5/95
* Data for 5/95 is provided to indicate seasonal traffic				

Source: Womak 1996 from Oklahoma State Highway Department, Traffic Count Division, 1995 and 1996 Traffic Surveys

5.2.1.4 Economic Resources

Employment and Payroll

In October 1996, the total work force in Sequoyah County was 16,520, with an unemployment rate of 6.2 percent. The work force for Muskogee County was 30,670, with an average unemployment rate of 5.8 percent.

Local Government Revenues

Local government revenues are generated primarily by sales and ad valorem taxes. The budget for Muskogee County for 1996 was 4,247,612, all of which was from ad valorem taxes. The Sequoyah County budget was 1,520,358, approximately 60% of which is from ad valorem taxes, 20% from miscellaneous revenues, and 20% from a cash balance from the previous year. Revenues for county roads are funded by gasoline taxes. The cities of Muskogee, Sallisaw, Gore, Webbers Falls, and Vian receive income from sales taxes for city government funding.

5.2.2 Cultural Resources

The Facility was part of the land given to the Cherokee Nation after their move from the southeastern United States. The State of Oklahoma Historical Society lists Talonteeskee, the western capital of the Cherokee Nation which was located in the area from 1829 to 1839, as a location of interest. Dwight Mission was established in the area in 1821, and served the Cherokees until after the Civil War. The Carlile House, initially on the facility site, served at one time as a weigh station for a stage running between Fort Smith and Fort Gibson. This house has been moved to a location on U.S. Route 64, near State Route 10, where it is preserved as a public attraction.

The National Register of Historic Places (Federal Register 48(41): 8626-8679, March 1, 1983, and prior annual listings) lists a number of historic places in Sequoyah County and in nearby Haskell and Muskogee Counties. The Tamaha Jail and Ferry Landing in Haskell County are within about 10 miles of the SFC site. The historic places in Sequoyah County are Sequoyah's Cabin, about 25 miles east of the plant site; Dwight Mission, about 17 miles northeast of the plant site; and Parris Mound in Sallisaw, about 17 miles east-southeast of the site. The National Registry of Natural Landmarks has no listings for Haskell, Muskogee, or Sequoyah Counties (Federal Register 48(41): 8682-8704, March 1, 1983).

5.3 Geology, Hydrology and Seismicity

5.3.1 Geology

Geological information for the Facility is provided in the Draft Site Characterization Report, Section 3.3, dated February 2, 1996.

5.3.2 Groundwater

Groundwater and hydrogeology information for the site and site area are provided in the Draft Site Characterization Report, Section 3.4, dated February 2, 1996.

5.3.3 Surface Water

Surface water information for the site and surrounding area is provided in the Draft Site Characterization Report, Section 3.5, dated February 2, 1996.

5.3.4 Seismicity

5.3.4.1 Regional Seismicity

The area of East Central Oklahoma where the SFC facility is located lies in a quiet seismic region of the United States. Although distant earthquakes may produce shocks strong enough to be felt in this area, the region is considered to be one of minor seismic risks. (Figure 5-2).

The seismically active regions closest to the site are the El Reno-Nemaha Ridge area located in Oklahoma, Kansas, and Nebraska, and the New Madrid area in Missouri. The probability of serious damage to the SFC facility from earthquakes occurring in either area is remote.

A recent probabilistic acceleration map of the contiguous United States (Figure 5-3) indicates that the horizontal acceleration at the site, with 90% probability of not being exceeded in 50 years, is less than 5% of gravity, which will produce only a small earthquake. On the basis of the historic seismicity record and the tectonic framework of the region, it is highly unlikely that a large-magnitude earthquake will affect the site.

5.4 Meteorology, Air Quality Visibility and Noise

5.4.1 Meteorology and Climate

Meteorology and climatology information is provided in the Draft Site Characterization Report, Section 3.2, dated February 2, 1996.

5.4.2 Air Quality

5.4.2.1 Ambient Air Quality

Oklahoma has adopted air quality standards (Table 5.4-1) that are very similar to the National Ambient Air Quality Standards.

Table 5.4-1 Oklahoma Air Quality Standards[1]

		Standard ($\mu g/m^3$)	
Pollutant	Averaging Time	Primary	Secondary
Sulfur dioxide	annual	80[1]	1300
	24-h	365[2]	
	3-h		
Nitrogen dioxide	annual	100[1]	100[1]
Ozone	1-h	235[5]	235[5]
Non-methane Hydrocarbons	3-h	160[2][4][5]	160[2][4][5]
Carbon Monoxide	8-h	10,000[2]	10,000[2]
	1-h	40,000[2]	40,000[2]
PM-10	annual	50[3]	50[3]
	24-h	150	150
Lead	Calendar Quarter	1.5[7]	1.5[7]

(1) Annual Arithmetic Mean
(2) Not to be exceeded More than Once per Year
(3) The standard is attained when the expected arithmetic mean concentration is equal to or less than the numerical standard determined by Appendix K Part 50 CFR 40
(4) Measured between 6 a.m. and 9 a.m.
(5) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 parts per million is equal to or less than 1, as determined by Appendix II for Part 50 of Chapter I, CFR 40
(6) Guide only value to EPA, to be used in planning, not a Federal Standard
(7) Maximum Arithmetic Mean averaged over a calendar quarter

A small area near the juncture of Sequoyah, Haskell and Muskogee counties could be affected by airborne effluents from the Sequoyah Facility. The air quality in these counties is classified as "better than national standards" for Total Suspended Particulates and SO_2. For CO, NO_x and Ozone, the air quality cannot be classified. Generally, this means that there are insufficient data to establish a classification under Environmental Protection Agency (EPA) regulations. This is not uncommon in a clean air region such as eastern Oklahoma. Air quality monitoring results from the station nearest the site are presented in Table 5.4-2.

Table 5.4-2 Ambient Air Quality in the General Vicinity of the Site

Pollutant	Averaging period	Year	Concentration	Percent of standard
Sulfur dioxide	annual	1990	.015 ppm	
		1991	.009 ppm	
		1992	.007 ppm	
		1993	.003 ppm	
		1994	.003 ppm	
		1995	.004 ppm	
	24-h	1990	.051 ppm	
		1991	.031 ppm	
		1992	.037 ppm	
		1993	.019 ppm	
		1994	.025 ppm	
		1995	.030 ppm	
	3-h	1990	.172 ppm	
		1991	.128 ppm	
		1992	.124 ppm	
		1993	.102 ppm	
		1994	.094 ppm	
		1995	.083 ppm	
Nitrogen dioxide	annual	1990	.007 ppm	
		1991	.007 ppm	
		1992	.008 ppm	
		1993	.009 ppm	
		1994	.008 ppm	
		1995	.007 ppm	
	1-h	1990	.078 ppm	
		1991	.056 ppm	
		1992	.046 ppm	
		1993	.069 ppm	
		1994	.050 ppm	
		1995	.044 ppm	
Inhalable particulate matter	annual	1990	25 $\mu g/m^3$	50
		1991	27 $\mu g/m^3$	54
		1992	27 $\mu g/m^3$	54
		1993	33 $\mu g/m^3$	66
		1994	31 $\mu g/m^3$	62
		1995	33 $\mu g/m^3$	66

Data from the Water Treatment Plant Monitoring Site, Muskogee, OK
Approximately 35 miles Northwest of the Sequoyah Fuels Facility

5.4.2.2 Prevention of Significant Deterioration

In addition to ambient air quality standards, which represent an upper bound on allowable pollution concentrations, there are national standards for the prevention of significant deterioration (PSD) of air quality (40 CFR 51.166). The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable *concentrations* of pollutants, while PSD requirements provide maximum allowable *increases in concentrations* for areas already in compliance with the NAAQS. PSD standards are therefore expressed as allowable *increments* in atmospheric concentrations of specific pollutants. Allowable PSD increments currently exist for three pollutants: NO_2, SO_2, and PM-10. PSD increments are particularly relevant when a major proposed action (involving a new source or a major modification to an existing source) may degrade air quality without exceeding the NAAQS , as would be the case, for example, in an area where the ambient air is very clean. One set of allowable increments exists for Class II areas, which cover most of the United States, and a much more stringent set of allowable increments exists for Class I areas, which are specifically designated areas where the degradation of ambient air quality is to be severely restricted. Class I areas include certain national parks and monuments, wilderness areas, and other areas as described in 40 CFR 51.166(e) and 40 CFR 81:400-437. Maximum allowable PSD increments for Class I and Class II areas are given in Table 5.4-3. The nearest PSD Class I areas to the SFC site the Buffalo National River Recreational Area in northeast Arkansas, approximately 100 miles east-northeast of the Facility, and the Caney Creek Wilderness Area in east central Arkansas, approximately 100 miles southeast of the site. The Wichita Mountains Wildlife Refuge in Oklahoma is located approximately 200 miles west of the site.

Table 5.4-3 Oklahoma Air Quality Standards - Prevention of Significant Deterioration

Pollutant	Maximum Allowable Increase (micrograms per cubic meter)
Class I Areas	
Particulate Matter	
Annual geometric mean	5
Twenty-four hour maximum	10
Sulfur dioxide	
Annual arithmetic mean	2
Twenty-four hour maximum	5
Three-hour maximum	25
Class II Areas	
Particulate Matter	
Annual geometric mean	19
Twenty-four hour maximum	37
Sulfur dioxide	
Annual arithmetic mean	20
Twenty-four hour maximum	91
Three-hour maximum	512
Class III Areas	
Particulate Matter	
Annual geometric mean	37
Twenty-four hour maximum	75
Sulfur dioxide	
Annual arithmetic mean	40
Twenty-four hour maximum	182
Three-hour maximum	700

5.4.2.3 Visibility

According to reports of the National Acid Precipitation Assessment Program (NAPAP), median visual range in eastern and east-central Oklahoma is about 30-50 km(18-30 miles) (NAPAP 1991). By way of comparison, median visual range is about 50-100 km (30-60 miles) in the central plains states, and about 150 km (90 miles) in western Colorado where there is less interfering material in the atmosphere from natural sources (e.g., humidity, gaseous organic emissions from vegetation) and anthropogenic sources (e.g., automobiles, industries).

5.4.3 Noise

The site is located in a rural area, and the plant was operated as an industrial facility. The primary sources of noise during the decommissioning process would be from the deconstruction of the buildings and from the movement of equipment during the excavation of soil and during the filling of the disposal cell. These activities would be limited to the site area, and would not represent a significant increase in the background noise at the location of the nearest resident, which is 2400 feet east-north-east.

5.5 Ecological Resources

5.5.1 Terrestrial Communities

The site is located in the oak-hickory savannah region, which is considered by various degrees of dominance of woodland and grassland. The region is within the transition area or ecotone between the eastern deciduous forest and the central prairies. The ecology of the area has been modified by grazing, by the clearing of forest for cultivation and pasture, and by the construction of reservoirs that destroyed bottomland forests.

The site itself is primarily an upland area. The woodlands are dominated by several species of oaks and hickories. Forests along streams and in river bottomlands are dominated by species such as cottonwood, sycamore, sweetgum, red oak, and water oak. Numerous dirt roads or trails have been cleared through most of the woodlands on the site to allow the passage of fertilizer spraying equipment. Pastures and fields on the site are dominated by Bermuda grass, rye and fescue.

The fauna of the site is dominated by both woodland and grassland species. Some 120 bird species breed in the region and a few hundred other species migrate through or overwinter in the area. Woodlands, brushlands, and wetlands usually support a larger number of bird species than do fields and pastures. About 65 mammals and 70 species of amphibians and reptiles occur in the region. Important game species that occur on the site include the bobwhite quail, white-tailed deer, and eastern cottontail.

The Sequoyah National Wildlife Refuge, located to the south and west of the SFC site, was established in 1970 to provide habitat for waterfowl and other migratory birds. It also provides food and cover for resident wildlife and contributes significantly to the recreational value of eastern Oklahoma. The refuge lies at the junction of the Canadian and Arkansas Rivers, and encompasses 20,000 acres, of which half is water. Most of the remainder is steep shoreline or bottomland surrounding the Robert S. Kerr Reservoir. The rich, river bottom with numerous ponds and sloughs, is ideal waterfowl habitat. A moderately rough and irregular shoreline, islands, and surrounding steep ridges provide an interesting and natural setting for outdoor activities.

Upland habitat on the refuge varies from open meadows to dense stands of mixed timber, mainly pecan, hickory, elm and oak. The bottomlands are primarily cottonwood and willow. This habitat provides homes for songbirds, hawks, bobwhite quail, squirrels, rabbits and a host of other animals. Many reptiles occur on the refuge. Rattlesnakes, copperheads and water moccasins (cottonmouth) comprise the poisonous varieties in the area.

5.5.2 Wetlands

Floodplains at the SFC site are associated primarily with the Illinois and Arkansas Rivers. A very narrow floodplain is located along the small stream at the northern border of the site. The Illinois and Arkansas Rivers in the immediate vicinity of the site are considered to be part of the Robert S. Kerr Reservoir. The normal pool elevation of the reservoir is 460 feet, which is about 10 feet above the original water level of the rivers at the SFC site prior to construction of the dam. Based on maintenance of a normal pool elevation of 460 feet at the Robert S. Kerr Lock and Dam, the maximum historical flood (1943) would cause the water level in the reservoir to raise to 479 feet at the site, while a 50-year flood would raise water levels at the site to only about 474 feet. Thus only a small part of the forage production area near the confluence of the rivers could be impacted by the maximum floods.

As presented in the RCRA Facility Investigation Report, 27 potential wetland areas on or near the SFC site were evaluated. Out of these, 5 met the current federal criteria for wetlands. None of these 5 acres were on SFC property.

5.5.3 Aquatic Communities

The Sequoyah Facility is located on the Illinois River embayment of the headwaters of the Robert S. Kerr Reservoir. The Illinois River, which is spring-fed, traverses a rugged, relatively undeveloped portion of Oklahoma. Consequently, the water is of relatively good quality and carries a low-sediment load. The reservoir provides habitat for a number of game-fish species including black bass, channel catfish, crappie and walleye. Nongame fish species are found in the shallow, weedy, brushy flats of the river, and a "put and take" rainbow trout fishery exists in the Illinois River below Tenkiller Dam, upstream of the site.

A study of the macrobenthis fauna of the Illinois River in the vicinity of the discharge of the Combination (or effluent) Stream was conducted by Doris and Russell during 1978-1979 and by Russell during 1980-1981. Results of these studies showed that the benthic fauna in the river is dominated on a seasonal basis by aquatic worms and chironomid larvae, but the damsel fly nymph, Argia sp., was dominant in the Combination Stream. The Combination Stream was found to have a more stable, less fluctuating environment than the Illinois River in the vicinity of the facility. In 1996 a pipeline was installed to route the Combination Stream to the Illinois River.

5.5.4 Ecological Risk

An ecological risk assessment was performed in conjunction with the cleanup criteria assessment. The screening-level assessment followed steps 1 and 2 of EPA's Ecological Risk Assessment Guidance For Superfund: Process For Designing and Conducting Ecological Risk Assessments (EPA, 1996). The process employs conservative assumptions regarding contaminant exposure and effects. Maximum measured media concentrations are compared to benchmark no effects thresholds for receptor species most exposed to and potentially most effected by the contaminants of concern.

5.5.4.1 Ecotoxicity and Potential Receptors

None of the contaminants of concern at the site are subject to significant biomagnification or bioaccumulation through the food chain. In general, the concentrations of radionuclides in living organisms decrease with each transfer in the food chain (University of Oklahoma, 1988).

Uranium has two modes of ecotoxicity. One through radiation dose, and the other through direct toxicity due to ingestion of uranium metal. The ecotoxicity of the radionuclides depend on the types of energies of radiation they emit, the tissues irradiated and their sensitivity and for internal exposures, the biological half life of the radionuclide in the receptor's body. Chemical toxicity effects include heavy metal poisoning that can impair kidney function. As with humans, ecological receptors are generally more sensitive to the metal toxicity than to radiological effects at low doses.

Arsenic occurs in the environment in several states and is readily volatilized to the atmosphere in it's reduced form. While arsenic can accumulate in water, there is no evidence of biomagnification in the aquatic food chain (Eisler, 1988). Arsenic is tolerated in small amounts even over extended periods, but larger doses can be acutely fatal. Chronic high exposure in mammals is associated with liver, kidney, and heart damage; hearing losses; brainwave abnormalities; rough hair coat; and bright red mucosa (Eisler, 1988).

Chronic ingestion of fluoride by animals can lead to bone, teeth and hoof abnormalities with severe cases of fluorosis resulting in diarrhea (Casarett and Doull, 1975).

Nitrate is a required nutrient, limiting productivity in many terrestrial and aquatic ecosystems, however, excessive use of nitrate fertilizer can lead to concentrations of nitrate in plant tissues that are toxic. Chronic nitrate ingestion by cattle can lead to decreased weight gain, decreased milk production, poor reproductive capacity, and digestive tract and respiratory disorders. Levels in animal feeds should not exceed 5000 mg/kg and death can occur through ingestion of 15,000 mg/kg of nitrate (Casarett and Doull, 1975). Ruminant animals may also develop methemoglobinemia through the consumption of nitrate and subsequent reduction in the rumen to nitrate to the more toxic nitrate. Uptake of nitrate into plant tissues can occur that are in excess of soil concentrations, particularly under adverse growing conditions (Casarett and Doull, 1975).

5.5.4.2 Identification of Complete Exposure Pathways

Site contaminants are currently found in surface soil, subsurface soil, groundwater, and surface water. Given that the site is primarily an industrial area, the ecological risks of physical disturbance under a no-action alternative are not evaluated. The primary complete exposure pathway of contaminants at the site under the no-action alternative is through exposure of biota to surface soil contaminants and exposed sediments. Under the no-action alternative, site surface water will be limited as it is assumed that the ponds at the site will not be maintained and will be allowed to dry up, exposing pond sediments. Uptake of surface soil and exposed sediment contaminants by plants and subsequent ingestion of plants along with incidental soil/sediment ingestion are the most likely routes of contaminant exposure to biota.

With shallow groundwater at about 10 foot deep at the site, and deep rooted vegetative cover sparse over much of the industrial area overlying the contaminant plumes, it is likely that there is limited exposure to plants from groundwater contaminants. Subsurface soil is not generally exposed to biota, with the possible exception of deep burrowing mammals.

5.5.4.3 Selection of Endpoints to Screen for Ecological Risk

Based on the exposure pathways, ecological receptors are selected based on the concept of "limiting species". For the purpose of screening risks, a receptor is chosen which may be most exposed and potentially sensitive to site contaminants. For this site, a small mammal (meadow vole) with a high rate of ingestion to body weight ratio and a small home range may be considered the limiting species. In addition, rooted plants may be exposed to contaminated groundwater. Therefore, screening benchmarks are developed for the site for the meadow vole.

5.5.4.4 Screening-level Ecological Effects Evaluation

Radiological benchmarks for uranium isotopes, radium-226 and thorium-230 are based on a 100 mrad/d dose rate to the limiting species (meadow vole) and are applied here as defined for Rocky Flats Environmental Technology Site (Higley, 1996). Meadow vole dietary benchmarks for chemical toxicity for uranium, arsenic and fluoride ingestion were taken from Sample et.al., 1996 and represent the concentration in the diet that would not be expected to result in adverse effects.

5.5.4.5 Uncertainty Assessment of the Application of the Benchmarks

The radiological benchmarks were derived based on the scientific consensus that a 100 mrad/d dose rate has not been found to harm any biological population (IAEA, 1992). The radiological benchmarks derived for Rocky Flats with site specific data are assumed to be applicable to this site given the similarity of the habitat and potential receptors at these sites.

The benchmarks developed by Sample et.al., 1996 are based on the protection of individuals as derived from laboratory studies of related species. Extrapolations to site species from test species and the effects of multiple contaminants on receptors introduces uncertainty into any screening assessment using benchmarks. Benchmarks derived to protect individuals are conservative if the objective (assessment endpoint) is to protect populations, communities and ecosystems from risk due to contaminant exposure.

The screening assessment employed here uses conservative assumptions which makes it very unlikely that a consequential decision error will be made. It is highly unlikely that this assessment will find that "The no-action alternative is protective of the environment when in fact the no-action alternative would cause significant risk to the environment." It is much more probable that the screening assessment provides evidence of more potential risk from contaminants than there is in fact.

Models of exposure are based on 100% bioavailability, 100% site use, and direct ingestion of the maximum observed contaminated media concentrations. While appropriate for this screening assessment of the no-action alternative, relaxation of these conservative assumptions is required before a realistic assessment of exposure con be applied to the derivation of site cleanup levels.

5.5.5 Species of Special Concern

Several special category species (endangered, threatened, or category 2) occur or may occur in the vicinity of the Sequoyah Fuels Facility.

Endangered species that might be found in the vicinity include the least tern, bald eagle, grey bat, Indiana bat, Ozark big-eared bat, and the peregrine falcon. The neosho madtom, a threatened species, and *Carex fissa*, a sedge listed as a category 2 species, may also be found in the area.

Because of specific habitat requirements and general patterns of occurrence, it is unlikely that any of these species, with exception of the bald eagle, would be found on the Sequoyah Fuels Facility. Bald eagles winter at Robert S. Kerr Reservoir and there are at least a few resident breeding pairs. It is likely that some individuals will visit the Sequoyah Fuels site. The quality of habitat in the 8 study areas of the Sequoyah Fuels site is poor compared with adjacent potential eagle foraging areas. Significant contaminant exposure to eagles through the food chain due to foraging for prey on site is not likely, given the paucity of prey in the industrial areas of the site.

5.6 Radiation Levels

According to "Natural Radiation Exposure in the United States," June, 1972, the total-body dose rate for the population in the vicinity of the site from natural radiation (Fort Smith, Arkansas area) is approximately 106 millirem/year. This dose rate includes 42.3 millirem/year from cosmic rays, 45.6 millirem/year from terrestrial sources, and 18 millirem/year from internal emitters.

6.0 Comparative Evaluation of Alternatives

Shallow land disposal, either on-site or off-site, is the ultimate disposition for all decommissioning wastes in each alternative presented in this study. Other, more exotic solutions were not seriously considered for lack of technical justification and the exorbitant cost associated with such solutions. A qualitative assessment of the incremental benefits of each of the alternatives as compared to SFC's proposed approach is presented below.

Alternative 1, which adds active groundwater remediation to the preferred alternative, would provide little or no improvement to the long-term dose and risk projections, since the drinking water pathway is improbable in the impacted areas. If groundwater in the area was used for human consumption, then Alternative 1 would afford a significant dose/risk reduction.

Alternative 2, which uses a lower leave-in-place value for uranium in soils, would provide a slight reduction in dose to the industrial worker inside the exclusion area. It would also provide a similar reduction in the dose to a resident farmer if the institutional controls failed to keep the farmer out of the exclusion area.

Alternative 3, which includes solidification of all contaminated soils to form a monolith, provides a slight reduction in direct dose from the disposal cell as well as some additional attenuation of radon emissions. Furthermore, the monolithic waste form would further inhibit intrusion into the waste material.

Alternative 4, which provides a degree of retrievability to the waste, preserves the option to move the waste to another location or to further treat it at some point in the future. SFC does not foresee providing funding for these potential future activities, thus there is essentially no benefit to this alternative.

Alternative 5, which provides for off-site disposal of solidified sludges, etc., would result in a reduction of greater than 95% in the amount of radium and thorium placed in the on-site disposal cell. This reduction in the radon precursors would result a reduction in the amount of radon emitted from the waste. However the net reduction in the amount of radon escaping from the cell would be small, since the cell is designed to contain the radon until the majority of it decays. Further, the off-site disposal area would experience a net gain in source term quantity and dose by the amount removed from the SFC site.

Alternative 6 is the same as Alternative 5, except that the sludges, etc., would be de-watered rather than solidified, thereby reducing the overall cost of the project.

Alternative 7, Off-site Disposal, moves the entire dose to another location leaving near background conditions at the site. This alternative does make an additional 85 acres available for unrestricted use. At an estimated value of $750/acre this amounts to $64,500 which is a very small fraction of the cost to achieve this condition. This alternative cannot be justified on an ALARA basis.

In all cases, there would be economic benefits to the local economy including salaries for the labor force and purchase of materials and supplies. This benefit would be roughly proportional to the cost of each alternative. An estimated cost for each of the decommissioning alternatives is summarized in Table 6-1.

Table 6-1 Cost Evaluation

		($,000)
Proposed Decommissioning Approach		23,044
Alternative 1: On-site Disposal with Groundwater Remediation	1-A 1-B	14,615 17,115
Alternative 2: On-Site Disposal with Remediation of all Soils Greater Than 40 μgU/g		28,231
Alternative 3: On-Site Disposal with Solidification of all Soils Greater Than 40 μgU/g (Monolith Design)		43,629
Alternative 4: On-Site Retrievable Storage		35,892
Alternative 5: Off-Site Disposal of Solidified Sludges, Sediments and Residues		107,142
Alternative 6: Off-Site Disposal of De-Watered Sludges, Sediments and Residues		75,543
Alternative 7: Off-Site Disposal of All Contaminated Materials		174,385

APPENDICES

Appendix A: SFC Decommissioning Project 4, Siting Study for On-Site Disposal, Morrison-Knudsen Corp., September 24, 1996

Appendix B: SFC Decommissioning Project 4, Disposal Cell Design - Review of Regulations and Design Specifications, Morrison-Knudsen Corp., September 30, 1996

Appendix C: SFC Decommissioning Project 4, Disposal Cell Design - Conceptual Designs and Cost estimates for Disposal Cells in Process Area and Fertilizer Pond Area, Morrison-Knudsen Corp., September 30, 1996

Appendix D: Conceptual Design Report - Decommissioning, Excavation, and Stabilization/Solidification Program, Earth Sciences Consultants, Inc., November 22, 1996

Appendix E: Brazil Creek Minerals, Typical Fly Ash Test Results, October 31, 1996

Appendix F: Feasibility Study for Solidification of Radioactive Sludges, ETAS Corp., August 12, 1994

Appendix G: Impacted Material Volume and Activity Estimates Data, Assumptions and Calculation, December 13, 1996

Appendix H: Sequoyah Facility Waste Evaluation and Size Reduction/Decontamination Facility Report, B&W Nuclear Environmental Services, Inc., November 7, 1996

Appendix I: Sequoyah Fuels Decommissioning Project 7, Soil and Sludge Remediation, Morrison-Knudsen Corp., September 24, 1996

Appendix J: Decommissioning Cleanup Criteria, Sequoyah Fuels Corporation, Roberts/Schornick & Associates, Inc., December 4, 1996

Appendix K: No Action Alternative Risk Assessment, Sequoyah Fuels Corporation, Roberts/Schornick & Associates, Inc., December 4, 1996

Appendix L: Passive Attenuation of Groundwater Constituents, Roberts/Schornick & Associates, Inc., November 27, 1996

Appendix M: Conceptual Design of Alternatives for Remediation of Shallow Bedrock Groundwater

Appendix N: Evaluation of Impact of SFC Groundwater on Robert S. Kerr Reservoir

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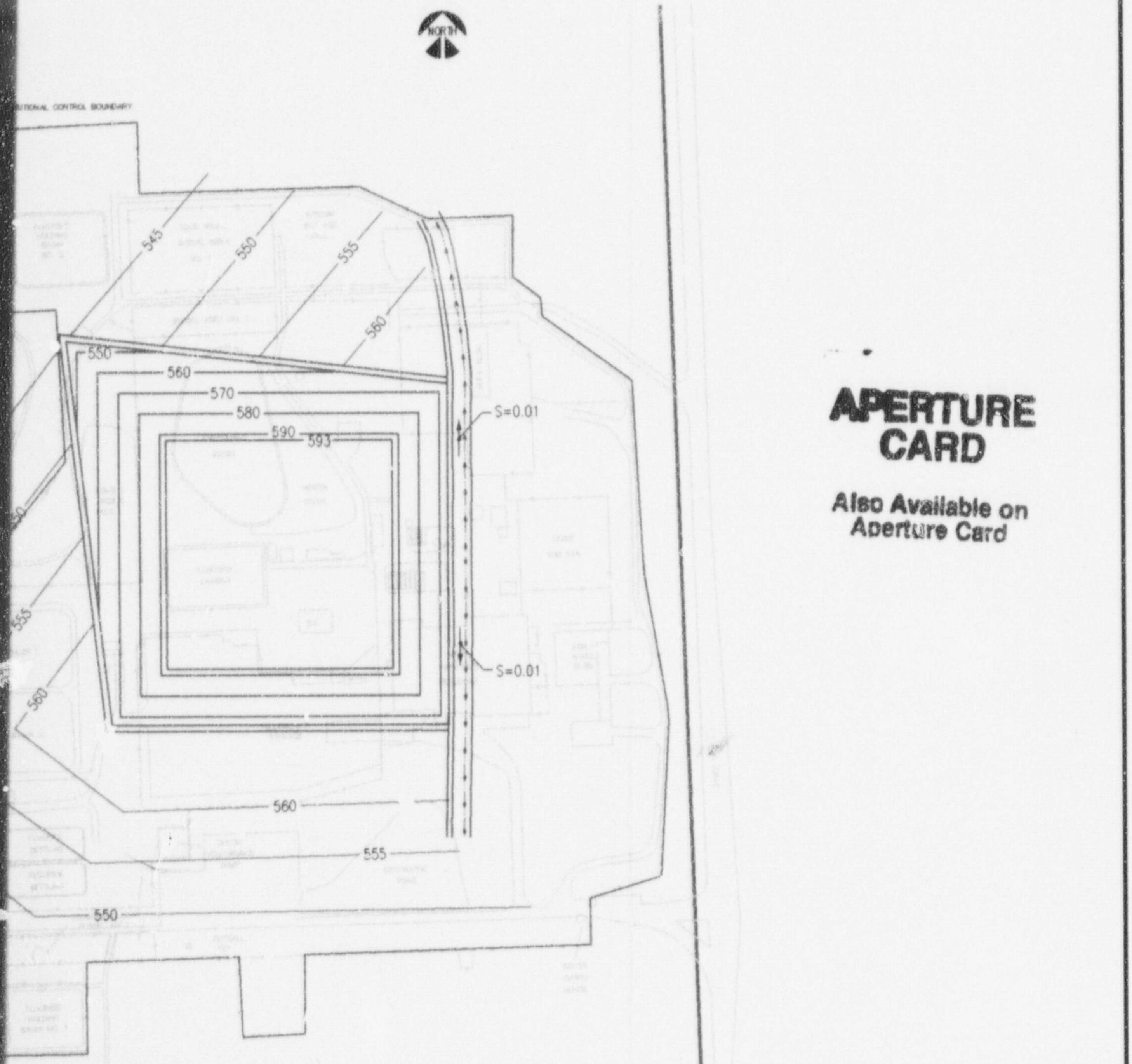
FACILITY BOUNDARY
FACILITY BOUNDARY
INSTITUTIONAL CONTROL BOUNDARY

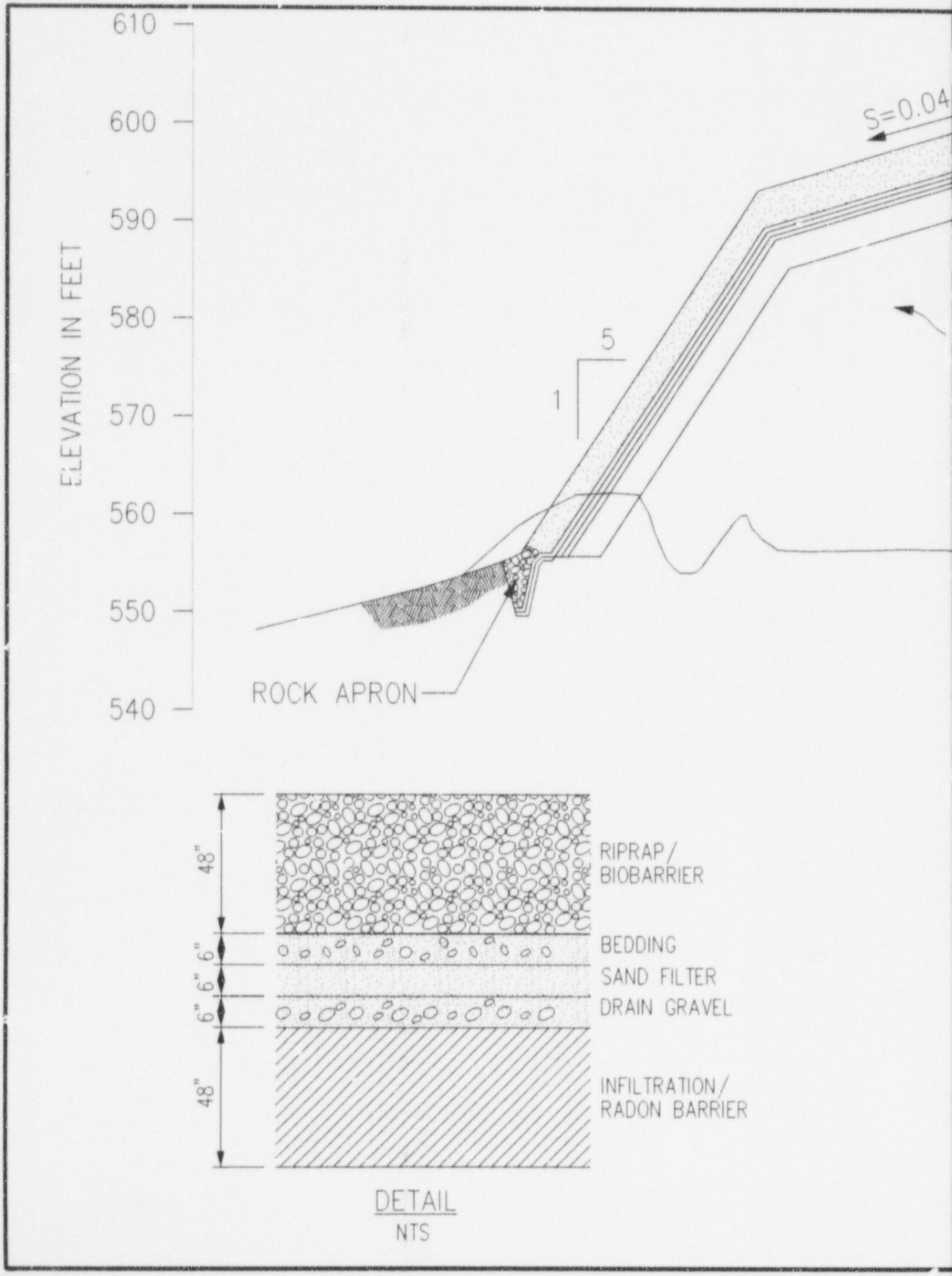


APERTURE CARD

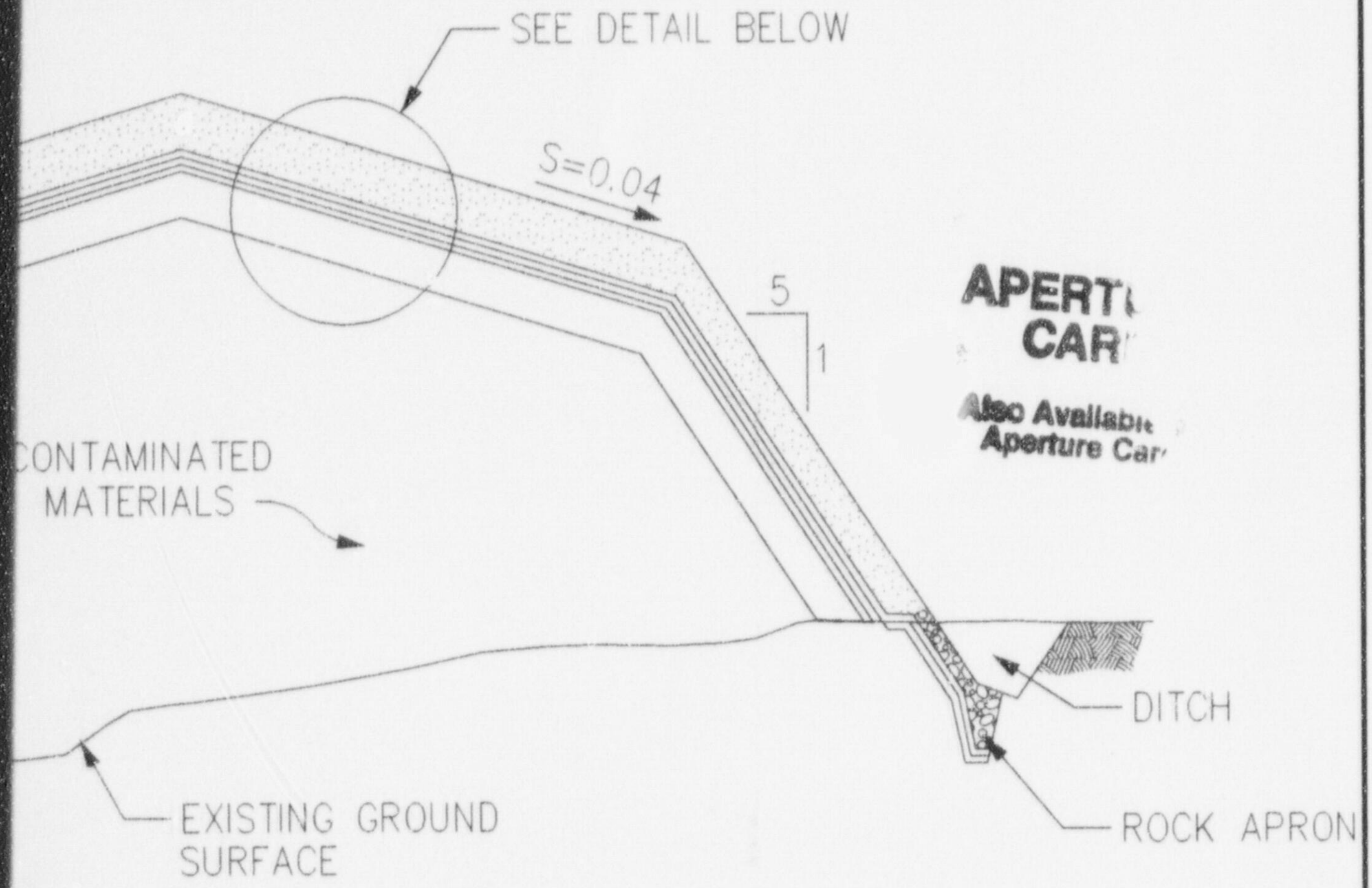
Also Available on Aperture Card

9810220310-01

SEQUOYAH FUELS CORPORATION DECOMMISSIONING ALTERNATIVES STUDY	
TITLE: DISPOSAL CELL FOOTPRINT	
PREPARED BY: SFC	FILENAME: NRC0006A
REVIEWED BY: CH	FIGURE 2-1
DATE: 12/11/96	



610
600
590
580
570
560
550
540
ELEVATION IN FEET
S=0.04
5
1
ROCK APRON
48"
6"
6"
6"
48"
RIPRAP/
BIOBARRIER
BEDDING
SAND FILTER
DRAIN GRAVEL
INFILTRATION/
RADON BARRIER
DETAIL
NTS



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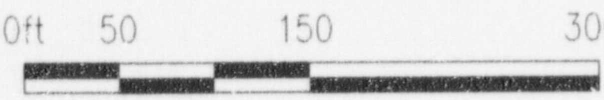

SEQUOYAH FUELS CORPORATION DECOMMISSIONING ALTERNATIVES STUDY	
TITLE: TYPICAL CROSS SECTION OF DISPOSAL CELL	
PREPARED BY: SFC	FILENAME: NRC0007A
REVIEWED BY: CH	FIGURE 2-2
DATE: 09/24/96	

SEQUOYAH FUELS CORPORATION
DECOMMISSIONING ALTERNATIVE STUDY

TITLE: MONITOR WELL LOCATIONS	
PREPARED BY: SFC	FILENAME: NRC0012A
REVIEWED BY: CH	FIGURE 2-3
DATE: 12/12/96	

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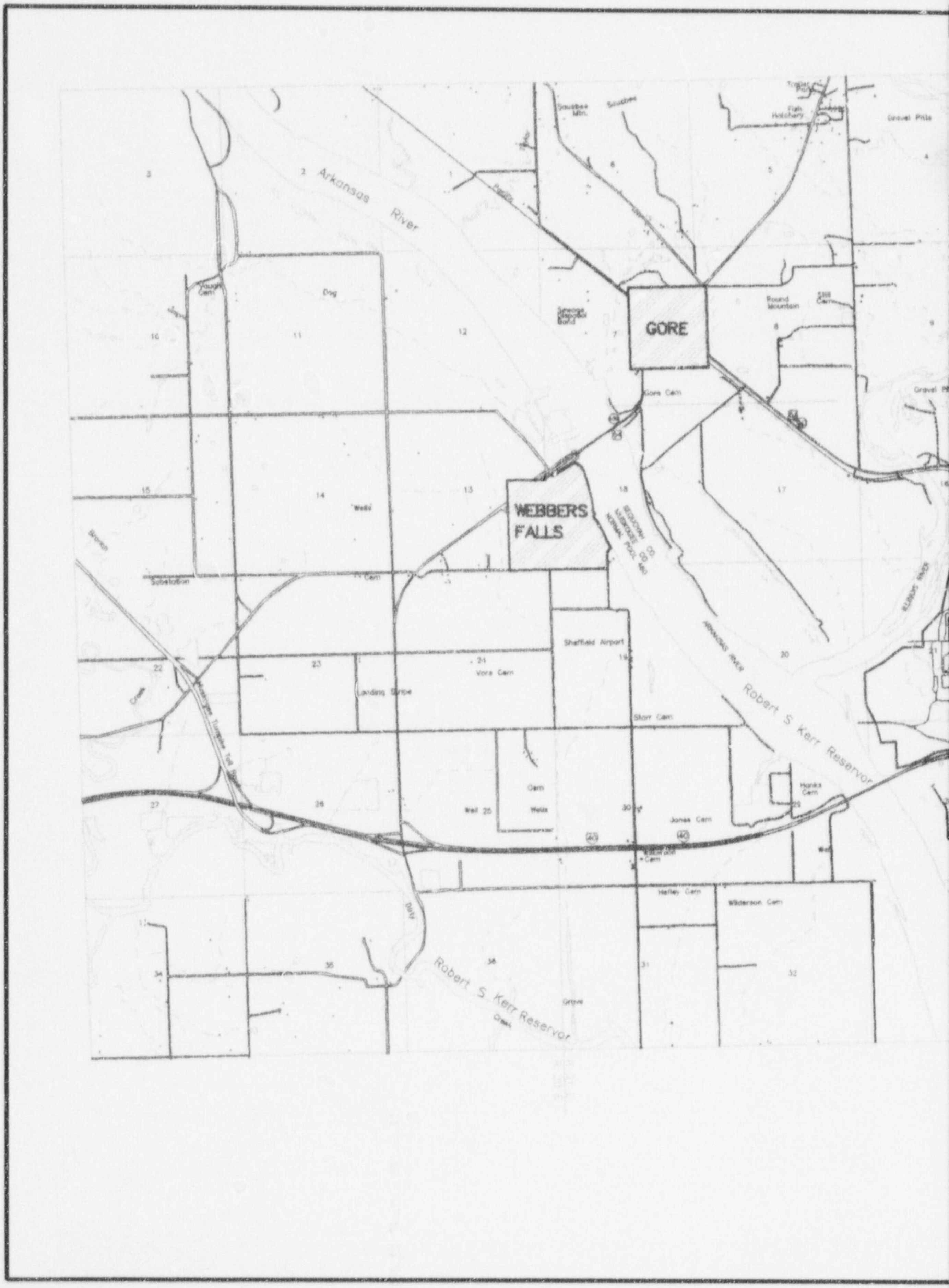
APERTURE CARD

Also Available on Aperture Card



Arkansas River
GORE
WEBBERS FALLS
Round Mountain
Gravel Pits
Fish Hatchery
Gore Cem
Sheffield Airport
Vora Cem
Landing Strip
Starr Cem
Jones Cem
Hanks Cem
Halley Cem
Wilkerson Cem
Substation
Dog
Wells
Robert S Kerr Reservoir
Arkansas River
Grove

SEQUOYAH FUELS CORPORATION
DECOMMISSIONING ALTERNATIVES STUDY

TITLE: SITE LOCATION		
PREPARED BY: SFC	FILENAME: NRCC008A	
REVIEWED BY: CLH	FIGURE 5-1	
DATE: 12/10/96		

9810220310 04

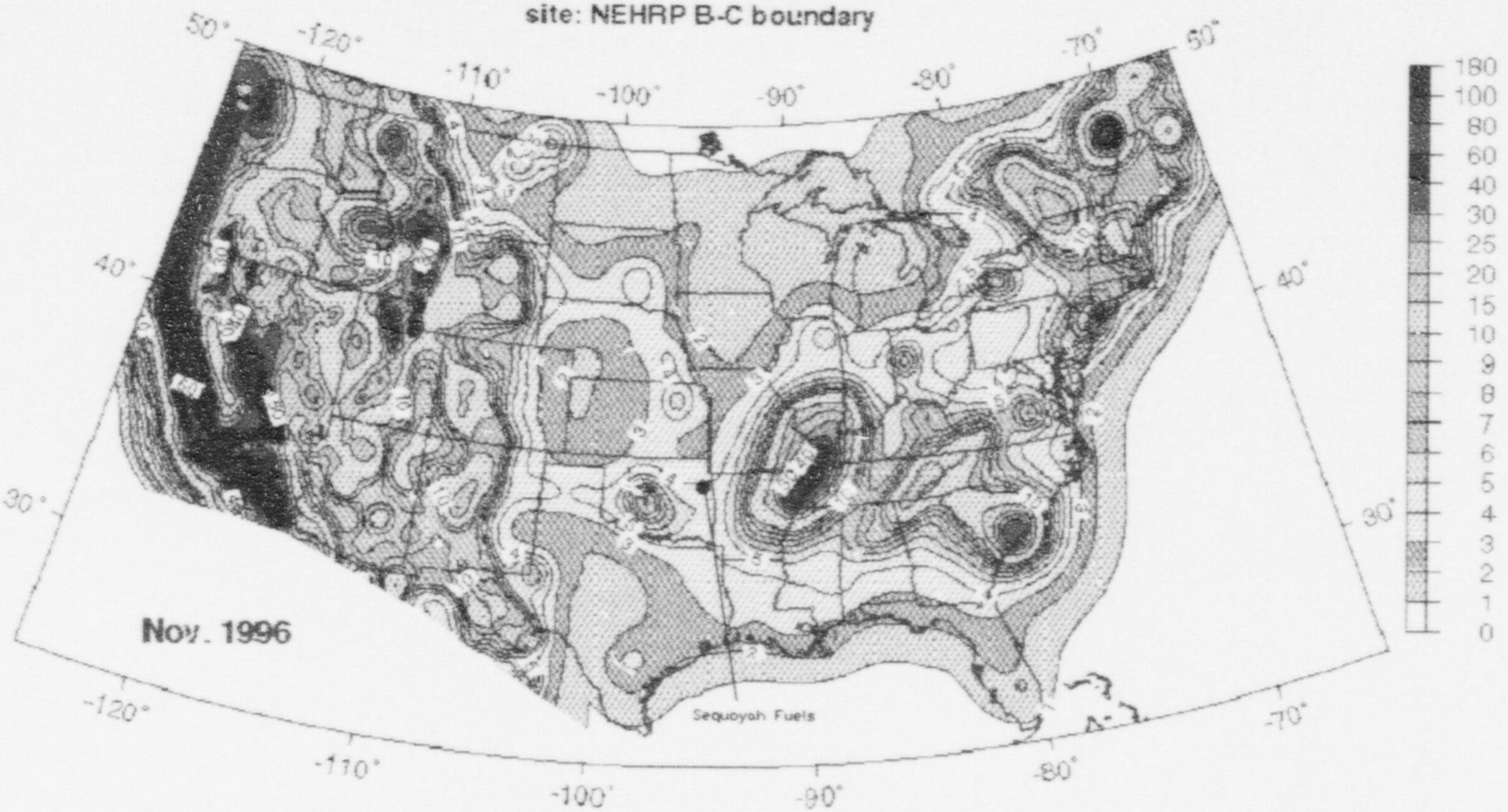
EARTHQUAKE SHAKING HAZARD MAP

Source: United States Geologic Survey

SEQUOYAH FUELS CORPORATION DECOMMISSIONING ALTERNATIVES STUDY	
TITLE: Seismic Risk Map Of The United States	
PREPARED BY: SPC	FILENAME: NRC0010A
REVIEWED BY: CLH	FIGURE 5-2
DATE: 7/8/98	

Peak Acceleration (%g) with 5% Probability of Exceedance in 50 Years

site: NEHRP B-C boundary



U.S. Geological Survey

National Seismic Hazard Mapping Project

SEQUOYAH FUELS CORPORATION DECOMMISSIONING ALTERNATIVES STUDY	
TITLE: PRELIMINARY MAP OF HORIZONTAL ACCELERATION	
PREPARED BY: SPC	FILENAME: NRC0010B
REVIEWED BY: CLH	FIGURE 5-3
DATE: 7/8/98	