RAS 9638

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CALCULATION SUMMARY SHEET (CSS)

Document Identifier 32 – 2400589 - 00

Title TEEB Soil Concentration & Integrated Liner Dose

PREPARED BY:		REVIEWED BY: METHOD: ☒ DETAILED CHECK ☐ INDEPENDENT CALCULATION	
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:OST CENTER 41757	REF. PAGE(S) 23	TM STATEMENT: REVIEWER INDEPENDENCE *[signature] 11/18/04*	

'URPOSE AND SUMMARY OF RESULTS

'his calculation documents the determination of the expected integrated radiation absorbed dose to the Treated Effluent :vaporative Basin (TEEB) liner after 30 years (assumed 30 years of waste addition at a design basis input of 570 grams of ıranium per year) of operation. The integrated dose from uranic waste deposited in the TEEB is expected to be about 22 Rad. The integrated dose from background occurring radionuclides in site soils if used to line the basin (plus cosmic-ray :xposure) would add approximately 12.8 Rad over the same 30 year period, or about 37% of the total dose of approximately .5 Rad. This integrated dose represents a very small fraction of typical integrated dose tolerances of many types of plastics ıat can range between 1E+04 and 1E+07 Rad before threshold effects from ionizing radiation are detectable.

If both the primary and secondary TEEB liners were assumed not to have been used, the depth of soil directly under the 'EEB that would be necessary to mix the entire 30 year design basis waste addition to concentrations approximately :quivalent to measured levels of natural uranium background at the NEF New Mexico site would be about 19.75 feet. This ıixing depth includes the first 3 feet of clay used as part of the engineered TEEB design.

Ion-Safety Related Calculation: Results from this calculation are not intended to be used for final design of safety-related systems, structures, or components. This calculation was prepared and reviewed in accordance with FANP QA procedures.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT.		THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK
CODE/VERSION/REV	CODE/VERSION/REV	
		☐ YES ☒ NO

LES Exhibit 10

LES-05266

Template = SECY-028

SECY-02

U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of Louisiana Energy Services, L.P.

Docket No. 70-3103 Official Exhibit No. LES 10

OFFERED by: (Applicant/Licensee) Intervenor ____

NRC Staff Other ____

IDENTIFIED on 2/7/05 Witness/Panel Harper/Peery

Action Taken: (ADMITTED) REJECTED WITHDRAWN

Reporter/Clerk Bethany Engel

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ADJUDICATIONS STAFF

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DESIGN VERIFICATION CHECKLIST

Document Identifier 32 – 2400589 - 00

TEEB Soil Concentration & Integrated Liner Dose

1.	Were the inputs correctly selected and incorporated into design or analysis?	☒ Y	☐ N	☐ N/A
2.	Are assumptions necessary to perform the design or analysis activity adequately described and reasonable? Where necessary, are the assumptions identified for subsequent re-verifications when the detailed design activities are completed?	☒ Y	☐ N	☐ N/A
3.	Are the appropriate quality and quality assurance requirements specified? Or, for documents prepared per FANP procedures, have the procedural requirements been met?	☒ Y	☐ N	☐ N/A
4.	If the design or analysis cites or is required to cite requirements or criteria based upon applicable codes, standards, specific regulatory requirements, including issue and addenda, are these properly identified, and are the requirements/criteria for design or analysis met?	☒ Y	☐ N	☐ N/A
5.	Have applicable construction and operating experience been considered?	☒ Y	☐ N	☐ N/A
6.	Have the design interface requirements been satisfied?	☐ Y	☐ N	☒ N/A
7.	Was an appropriate design or analytical method used?	☒ Y	☐ N	☐ N/A
8.	Is the output reasonable compared to inputs?	☒ Y	☐ N	☐ N/A
9.	Are the specified parts, equipment and processes suitable for the required application?	☐ Y	☐ N	☒ N/A
10.	Are the specified materials compatible with each other and the design environmental conditions to which the material will be exposed?	☐ Y	☐ N	☒ N/A
11.	Have adequate maintenance features and requirements been specified?	☐ Y	☐ N	☒ N/A
12.	Are accessibility and other design provisions adequate for performance of needed maintenance and repair?	☐ Y	☐ N	☒ N/A
13.	Has adequate accessibility been provided to perform the in-service inspection expected to be required during the plant life?	☐ Y	☐ N	☒ N/A
14.	Has the design properly considered radiation exposure to the public and plant personnel?	☒ Y	☐ N	☐ N/A
15.	Are the acceptance criteria incorporated in the design documents sufficient to allow verification that design requirements have been satisfactorily accomplished?	☒ Y	☐ N	☐ N/A
16.	Have adequate pre-operational and subsequent periodic test requirements been appropriately specified?	☐ Y	☐ N	☒ N/A
17.	Are adequate handling, storage, cleaning and shipping requirements specified?	☐ Y	☐ N	☒ N/A
18.	Are adequate identification requirements specified?	☐ Y	☐ N	☒ N/A
19.	Is the document prepared and being released under the FANP Quality Assurance Program? If not, are requirements for record preparation review, approval, retention, etc., adequately specified?	☒ Y	☐ N	☐ N/A

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DESIGN VERIFICATION CHECKLIST

Document Identifier 32 - 2400589 - 00

Comments:
TEEB Soil Concentration & Integrated Liner Dose

None

Verified By:	Nicholas Panzarino	N. M. Panzarino	11/18/04
(First, MI, Last)	Printed / Typed Name	Signature	Date

Framatome ANP, Inc., *an AREVA and Siemens company*

Table of Contents

1.0 Purpose / Objective:

This calculation evaluates the following two radiological aspects of the design of the Treated Effluent Evaporative Basin (TEEB) at the National Enrichment Facility (NEF) in New Mexico:

(1) In comparison to the natural uranic background concentration measured in NEF site area soils, what volume of soil (assuming no basin liner barrier) would be necessary to mix the design basis liquid waste effluent discharge over the entire 30 year operating life of the facility such that the uranic waste soil concentration would equal the local natural occurring levels.

(2) What is the expected integrated radiological absorbed dose to the TEEB first liner from 30 years of addition of the annual design basis liquid waste effluent discharge to the TEEB.

2.0 Design Inputs and Assumptions:

This is a non-safety related calculation and therefore contains no "key" assumptions as defined by FANP procedures.

2.1 Input values for calculations include items in Table 1:

Table 1
Input Values and Assumptions

Parameter	Value	Reference
Annual uranic waste discharge to the TEEB	570 grams/yr U (390 uCi/yr)	LES NEF ER pg 4.12-9 Ref.3
Surface area of the TEEB (conversion factor = 43,560 ft^2/acre)	0.72 acres (31,363 ft^2)	Ref. 8
Operating life of the TEEB	30 years	Ref. 1
Depth of clay in TEEB to first liner	1 ft	Ref. 1
Depth of clay in TEEB below second (bottom) liner	2 ft	Ref. 1
Assumed clay density (using midpoint of typical range)	2.2 grams/cc (1.8 to 2.6 g/cc)	Ref. 7
Assumed soil density below the TEEB	1.7 grams/cc	Ref. 7
The mix ratio of uranic nuclides in natural uranium based on isotopic radioactivity per unit mass of U	U-234 = 0.485 (uCi) U-235 = 0.029 (uCi) U-236 = 0.002 (uCi) U-238 = 0.485 (uCi) Total = 1.0 (uCi of U)	Ref. 3
Background Radioactivity Soil Concentrations (measured)	See Table 2	Ref. 1 & Ref. 5
Energy emitted per nuclear transformation by alpha, electron and photon emissions	See Table 5	Ref. 2, Table A.1.
Isotopic Activity Content per Metric Ton of Uranium	See Table 3	Ref. 4
Energy Conversion Constant	6.2418 Mev/erg	Ref. 7, Table 2.12
1 Rad absorbed dose equals:	100 ergs/g	Ref. 7, Table 2.12
1 Bq (Bequerel) activity equals:	1 nt/sec (nt = nuclear transformation)	Ref. 7, Table 2.12

2.2 For the determination of energy deposition to the TEEB liner from uranic waste, energy deposition values from FGR #12 (Reference 2) are used, along with the assumption that the emitting media (TEEB clay) is a semi-infinite medium (i.e., volume of clay above the liner with respect to uranic waste) and that all the alpha, beta and photon energy emitted per nuclear transition is absorbed. This is appropriate for short range alpha and beta emissions, and conservative for gammas in a finite medium.

2.3 For determination of the integrated dose to the TEEB liner, it is assumed that all the nuclide waste activity added to the basin precipitate out of the water column and deposits in only one quarter of the basin's first clay layer volume, thereby maximizing the radionuclide concentration on only a small portion of the liner. The volume and mass of clay is equal to the surface area of the TEEB (31,363 ft^2) times the thickness of the clay layer (1 ft) times the fraction of the basin assumed to be impacted by deposition of uranic waste (0.25):

$$31{,}363\ ft^3 * 0.25 = 7{,}840.8\ ft^3 \text{ or } 222.03\ m^3$$ for the affected volume of the TEEB, and

$$222.03\ m^3 * 1.70E{+}06\ g/m^3 = 3.775E{+}08 \text{ grams of clay.}$$

2.4 For the determination of energy deposition to the TEEB liner from measured background radionuclides, energy deposition values from FGR #12 (Reference 2) are also used, along with the assumption that the emitting media (TEEB clay) is a infinite medium (i.e., volume of clay both above and below the liner impact the liner itself) and that all the alpha, beta and photon energy emitted per nuclear transition is absorbed. This is appropriate for short range alpha and beta emissions, and conservative for gammas in a finite medium.

2.5 All progeny in each of the natural occurring decay series (i.e., Uranium, Thorium and Actinium) are assumed to be in secular equilibrium with the long lived parent such that each nuclide in the decay chain is present at the same concentration as measured for the parent. To this are added the contributions from other individual nuclides measured in the soil.

2.6 The elevation of Eunice, MN, is 1046 meters above mean sea level, as found at http://www.heavens-above.com/.

2.7 The cosmic-ray dose rate in air at 1000 meters above mean sea level is approximately 37 mrad/year as taken from figure 2.4 of Reference 9.

3.0 Identification of Computer Usage:

Computations were made using Microsoft EXCEL spreadsheets run on a Dell personal computer with OS Microsoft Windows XP Professional, Version 5.1.2600 Service Pack 1 Build 2600. The Dell PC :

System Model: OptiPlex GX240
System Type: X86-based PC
Processor: x86 Family 15 Model 2 Stepping 4 GenuineIntel ~1994 Mhz
BIOS Version/Date: Dell Computer Corporation A03, 3/1/2002

The spreadsheet was checked by both visual inspection of equations and input values applied, and by hand calculation checks to verify that the intended operations were properly implemented by the spreadsheet.

4.0 Methodology:

4.1 Soil Equivalent Concentration to Background

Based on the design uranic waste input into the TEEB over its intended 30 year operating period, the total amount of uranium added to the basin is calculated, assuming no radioactive decay because of the long half life of the nuclides involved. The isotopic makeup of this total uranic waste quantity is then estimated under the assumption that the input stream reflects, on average, the isotopic composition of natural uranium, or the same as the feed material used in the plant. The resulting total isotope content is then equated to the measured background isotopic concentration in order to solve for the volume of soil necessary to make the waste concentration equal to the average background value. An equivalent depth below the TEEB is estimated from the necessary volume needed to equal measured soil concentrations by assuming that the effected soil lies directly below the footprint of the TEEB.

4.2 Basin Liner Energy Absorbed Dose Estimate

The design basis source term of uranic waste (assumed to be equivalent to a natural mix distribution based on the makeup of feed material) is assumed to be added to the TEEB on the first day of each year for 30 years (NEF license life). For simplification in modeling, it is also assumed that principle progeny have grown into the uranic waste material assuming a 20 year in-growth period (it is also shown that all significant contribution from progeny is reached with only a 1 year in-growth period). The soil concentration of uranic material and progeny are calculated based on the conservative assumption that all the waste precipitates out in only 25% of the basin area and instantaneously mixes in the clay volume from the surface down 1 foot to the first liner. From a dose modeling standpoint, the source term is assumed to form a semi-infinite volume such that all the energy from each nuclear transformation leaving a unit volume is equal to the energy coming in. As such, the energy per nuclear transformation data from FGR #12, Table A.1 for all nuclides assumed to be in the isotopic mix in the soil (Reference 2) are used to estimate the energy (and absorbed dose) to the basin liner that forms a boundary between the contaminated clay on top and the clean clay layer below. The integrated absorbed dose is the result of each years addition to the TEEB, building up over the 30 years, taking no credit for reduction due to decay due to the long half lives of the principal nuclides involved. In addition to the uranic waste discharged yearly to the TEEB, the basin liner would also be exposed to background radiation from radionuclides present in the soil both above and below the liner (infinite source geometry assumed about the liner), as well as from cosmic radiation, assuming no effective shielding by the soil itself. Background soil measurements were used to identify those radionuclides present in the soil at the NEF site. It was assumed for the Uranium, Thorium and Actinium decay series that all the radionuclides in each decay chain were in secular equilibrium with the primary long lived parent that marks each decay series, and as such exist at the same activity level as measured for the parent. The same energy per nuclear transformation-to-absorbed dose method as applied to the uranic waste stream is also applied to those background radionuclides in order to determine dose.

5.0 Calculations:

5.1 Soil Equivalent Concentration to Background

From the LES NEF ER, the annual design value uranic liquid waste content discharge to the TEEB is 570 grams (1.3 lbs) or equivalent 390 uCi assuming isotopic mix ratio for natural occurring uranium. The footprint of the TEEB is expected to cover approximately 0.72 acres (equal to 31,363 ft^2), and have a 1 foot thick clay layer on top of the first basin liner. Another 2 feet of clay will form a second layer below the second liner at the bottom of the basin.

Step 1: Total uranic waste radioactivity discharged to the TEEB over 30 years of design operation;

570 g/yr U * 30 yr = 17,100 g of U (natural mix)

390 uCi/yr U * 30 yr = 11,700 uCi of U (natural mix)

and by applying the fractional isotopic mix values for natural uranium to the total activity gives the expected accumulated (30 yr) uranium breakdown by isotope in the TEEB as follows:

U-234:	11,700 uCi * 0.485 = 5,674.5 uCi
U-235:	11,700 uCi * 0.029 = 339.3 uCi
U-236:	11,700 uCi * 0.002 = 23.4 uCi
U-238:	11,700 uCi * 0.485 = 5,674.5 uCi

Step 2: The concentration of accumulated (30 yr) uranic waste activity assumed to be distributed over the 1 foot thick clay layer than sits above the first basin liner in the TEEB is determined as follows:

Volume of clay: 31,363 ft^2 (area) * 1 ft (thickness) = 31,363 ft^3

Or 31,363 ft^3 * 2.832 E+04 cc/ft^3 = 8.881 E+08 cc

And with a typical density of clay being taken as 2.2 g/cc, the mass concentration of the uranic waste in the immediate basin clay material is found to be:

Total U: 11,700 uCi * [1/8.881 E+08 cc * 2.2 g/cc] = 5.99 E-06 uCi/g (or 5.99E+03 pCi/kg)

And by isotope of the uranium:

U-234:	5,674.5 uCi * [1/8.881 E+08 cc * 2.2 g/cc] = 2.90 E-06 uCi/g (or 2.90E+03 pCi/kg)
U-235:	339.3 uCi * [1/8.881 E+08 cc * 2.2 g/cc] = 1.74 E-07 uCi/g (or 1.74E+02 pCi/kg)
U-236:	23.4 uCi * [1/8.881 E+08 cc * 2.2 g/cc] = 1.20 E-08 uCi/g (or 1.20E+01 pCi/kg)
U-238:	5,674.5 uCi * [1/8.881 E+08 cc * 2.2 g/cc] = 2.90 E-06 uCi/g (or 2.90E+03 pCi/kg)

Step 3: Direct comparison of the 30 year accumulated uranic materials in the top 1 foot of TEEB clay to the measured background soil concentrations of uranium (see Table 2) shows for the two primary uranium nuclides that were detectable:

Nuclide	TEEB Waste (1 ft clay later)	vs	Background soil		ratio TEEB Waste/Background
U-234	2.90E+03 pCi/kg		180.2 pCi/kg		16.12
U-238	2.90E+03 pCi/kg		183.9 pCi/kg		15.77
			Average = 182.1 pCi/kg	Average =	15.94

Since the expected activity levels of U-234 and U-238 in a natural mix of uranium is expected to be approximately equal, we can average the observed values for the measured background for these two radionuclides to find a best fit estimate of the ratio of TEEB waste to measured background, which is seen above to be 15.94 on mass concentration basis. If we recognize that the assumed density of clay (2.2 g/cc) in the TEEB might be higher than typical soils (1.7 g/cc), then another correction should be applied if we what to see what volume of site soil would be needed to dilute the TEEB activity down to background levels.

Step 4: Volume Dilution Credit:

To find the depth of soil below the TEEB that would be needed to dilute the waste uranic material to be equal to the background levels, we first need to determine the mass of soil/clay needed to mix the 30 year total uranic content in. From Step 1 above, we see that the 30 year quantity of both U-234 and U-238 equals 5.674E+09 pCi. If we equate this to the desired observed background level concentration for these two nuclides in soil, we can solve for the required mass of soil:

5.674E+09 pCi / N kg = 182.1 pCi/kg

Therefore N kg = 5.674E+09 pCi /182.1 pCi per kg

N kg = 3.116E+07 kg mass of soil needed to mix TEEB activity

Now, since the density of the first 3 feet of the TEEB is clay taken to be 2.2 g/cc and the rest of the soil below the TEEB is assumed to average 1.7 g/cc, we can solve for the additional depth of soil below the TEEB needed to provide a total mass of 3.116E+07 kg (assuming that the lateral extent of the mixing is defined by the surface area of the total TEEB, or 31,363 ft^2.

Therefore 3.116E+07 kg = [31,363 ft^2 * 3 ft * 2.832E-02 m^3/ft^3 * 2.2 g/cc *1E+06 cc/m^3 * 1kg/1000g]

+ [31,363 ft^2 * K ft * 2.832E-02 m^3/ft^3 * 1.7 g/cc *1E+06 cc/m^3 * 1kg/1000g]

or 3.116E+07 kg = [5.862E+06 kg] + [1.510E+06 kg/ft * K ft]

or K ft = [3.116E+07 – 5.862E+06] / 1.510E+06

K ft = 16.75 ft of site soil needed below the TEEB

When the soil depth is added to the clay depth of 3 ft as part of the TEEB, the total depth from the top of the clay surface of the TEEB to the bottom of the soil column needed to mix 30 year Uranic material to background levels is:

Total depth = 3 ft (clay) + 16.75 ft (site soil) = 19.75 ft total.

5.2 Basin Liner Energy Absorbed Dose Estimate

Step1: Table 3 is taken from Reference 4 and provides a radionuclide activity breakdown (in curies) for each metric ton of natural uranium (U-235 = 0.711 wt%) assumed to added to the source term. Since the annual discharge to the TEEB is estimated to be 570 grams of uranium, an equivalent isotopic input to the TEEB can be calculated on the left hand side of Table 4. As an example of the calculations, we look at U-238:

From Table 3 for U-238, the conversion factor is 3.339E-01 Ci/MTU,

Therefore:

3.339E-01 Ci/MTU * 570 g U/yr * 1E-03 kg/g * 1E-03 MT/kg = 1.903E-04 Ci/yr for U-238 (see Table 4)

Step 2: Next, the concentration of activity in the TEEB clay after the first year's addition is calculated on Table 4 (right side). Taking the example of U-238 above, this is shown to be:

1.903E-04 Ci/yr /[222.03 m^3 * 1.7E+06 g/m^3] * 1Bq/27 pCi * 1E+12 pCi/Ci = 1.866E-02 Bq/g

[Note: As a conservative assumption for energy deposition per gram of material, the density of the clay in the TEEB is taken as 1.7 E+06 g/m^3, or that assumed for site area soils. This will maximize the radioactivity per gram of material and the resulting absorbed dose estimate to the liner.]

Step 3: Next, the total first year absorbed dose rate (Rad/yr) is calculated using the energy emitted per nuclear transformation data provided on Table 5 and the isotopic concentration in TEEB clay previously calculated on the right side of Table 4. As an example using U-238 from above, the following calculations show the conversion isotopic concentration to energy emitted per transformation to absorbed dose rate:

From Step 2, U-238 concentration equals 1.866E-02 Bq/g, (or equivalently 1.866E-02 nuclear transformations (nt) per second – gram, based on the definition of 1 Bequerel = 1 nt/sec) after one year's addition to the TEEB; therefore, for the energy associated with alpha emissions is:

1.866E-02 nt/sec-g * 4.187 Mev/nt / [6.2418E+05 Mev/ergs * 100 ergs/g-Rad] = 1.252E-09 Rad/sec

and 1.252E-09 Rad/sec * 3600 sec/hr * 8766 hr/yr = 3.951E-02 Rad/yr (infinite source geometry)

Therefore, since the assumption that the source lays above the liner in the TEEB, then the uranic waste stream source geometry that exposes the liner can be assumed to semi-infinite, and as a result we can divide the above infinite dose rate by 2.

3.951E-02 Rad/yr / 2 = 1.975E-02 Rad/yr from U-238 alpha (See Table 6)

The above calculations are repeated for beta and gamma emissions from all radionuclides deposited in the TEEB and the sum total taken for the total absorbed dose rate for one year of waste addition to the TEEB. Table 6 shows the result of this calculation.

As a check that the buildup of uranium progeny over time does not cause an underestimate of the total absorbed dose, Table 6 (1 yr decay and buildup) is repeated on Table 7, assuming a 20 year period for buildup of progeny. As can be seen from the two tables, the sum total of the absorbed energies is dominated by the uranium isotopes and their first & second progeny that due to relatively short half-lives have come into secular equilibrium within the first year of decay. As a result, there is no significant difference between the total absorbed dose with 1 year of in-growth versus 20 years of in-growth. This same conclusion also applies over the 30 year operating period of the TEEB liner.

Step 4: The accumulated 30 year integrated dose is found as a summation individual years dose impact as the waste activity is added to each year. The basic premise in this evaluation is that the same design quantity of uranic waste (570 grams/yr) is added to the TEEB each year for thirty years. Because of the long half life of the primary radioisotopes and the assumption that the buildup of all significant progeny takes place immediately and remains constant with regards to the 30 thirty year integration period, the annual absorbed dose rate from each year's addition to the TEEB can be added to the previous year total absorbed dose rate to find that years total dose and the accumulated dose.

From Table 7, the total absorbed dose rate from all energy emissions for all nuclides (4.776E-02 Rad/yr) is used in Table 8 to find each year's annual dose and the accumulated dose over the elapsed time. As an example, take the first three years of additions to the TEEB where each year's additions cause an increase in the annual dose rate:

1st year:	4.776E-02 Rad/yr	=	4.776E-02 Rad
2nd year:	4.776E-02 Rad/yr + 4.776E-02 Rad/yr	=	9.552E-02 Rad
3rd year:	4.776E-02 Rad/yr + 4.776E-02 Rad/yr + 4.776E-02 Rad/yr	=	1.433E-01 Rad
	Three year accumulative total dose	=	2.866E-01 Rad

The total absorbed dose at the end of the 30 year integration period is seen on Table 8 to be equal to 22.21 Rad to the first TEEB liner.

Step 5: For background absorbed dose contribution, the same process as described above is repeated for those radionuclides detected in site soils as shown on Table 2. Table 2 only indicates the results of gamma analysis for principle elements of the major natural decay series, along with individual nuclides commonly seen in background samples. In order to evaluate the full potential dose contributions from non-gamma emitters or those nuclides not reported in the gamma analysis, the potential dose contribution from each member of the primary natural occurring radioactive decay chains is added in with those nuclides measured in site soil samples.

Table 9 shows all the nuclides of the Uranium decay series and assumes that all progeny are present at the same concentration as that of the long live parent U-238 (measured values is the average of the U-238, U-234 pair combination as taken from Table 2). The same energy emitted per nuclear transformation data as taken from Table 5 and used above is applied to Table 9, assuming a infinite volume source, giving a total annual dose of 0.168 Rad/year. Since radioactive buildup and decay are assumed to be in balance in secular equilibrium, the annual dose rate is simply multiplied by 30 to estimate the 30 year integrated dose to the TEEB liner from this decay series, giving an absorbed dose of 5.05 Rad.

Table 10 and Table 11 repeat the same process of estimating the absorbed dose contribution from the Thorium and Actinium decay series, respectively, as explained above for the Uranium series. The 30 year integrated dose for the Thorium series is 4.79 Rad. The Actinium decay chain contributes another 0.26 Rad (See table 11).

Table 12 repeats the same absorbed dose estimate for two other individual radionuclides reported as detected in soil on Table 2. Cesium-137 and K-40 contribute an additional 1.59 Rad over a 30 year period, assuming no decay reduction in the 30 year half-life Cs-137 concentration.

Data on cosmic-ray absorbed dose rate at the elevation of NEF site in New Mexico (37 mrad/yr) were taken from Reference 9, multiplied by 30 years and added to the background contribution, as shown on Table 13.

Table 2 NEF Site Soil Background Radiological Measurements - pCi/kg

NEF Site Location #	Ac-228	Cs-137	K-40	Th-228	Th-230	Th-232	U-234	U-235	U-238
SS-2	181	11.5	3720	146	157	204	159.2	6.6	146.8
SS-6	151	80.7	3780	207	136	163	165	6.7	158
SS-9	168	84	3650	154	160	164	168.4	10.6	161.2
SS-11	175	83.5	3750	175	155	181	165.4	11.6	168.5
SS-12	205	57.6	3610	207	163	196	159.4	11.1	162.5
SS-13	172	32.6	3660	199	149	194	143	9.7	157.6
SS-15	156	74	3860	211	161	207	161.5	7.5	156.4
SS-16	201	89.9	3770	200	183	188	165.4	6.4	152.8
#1	169	30.2	3990	169			210		247
#2	201	13.3	3500	201			242		192
#3	178	50.1	4220	178			180		211
#4	200	48.7	3970	200			182		184
#5	230	229	5090	230			156		156
#6	173	63.6	3330	173			179		144
#7	184	87.7	4060	184			269		244
#8	141	75.2	4000	141			184		240
#9	172	88.5	3770	172			186		210
#10	212	76.6	4340	212			169		218
Average =	181.6	70.9	3892.8	186.6	158	187.1	180.2	8.8	183.9

Note: Sample analyses for locations SS-2 through SS-16 are taken from Reference 1. Samples marked # are from Reference 5.

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Table 3*

Ci/MTU as a Function of Decay Time
for Natural Uranium
(Feed material 0.711 wt% U-235)

nuclide	1.0YR	20 YR
TL207	5.108E-09	1.693E-06
TL208	2.089E-16	3.483E-13
PB210	6.587E-12	4.633E-08
PB211	5.123E-09	1.698E-06
PB212	5.813E-16	9.695E-13
PB214	6.507E-10	2.595E-07
BI210	6.587E-12	4.634E-08
BI211	5.123E-09	1.698E-06
BI212	5.813E-16	9.695E-13
BI214	6.507E-10	2.595E-07
PO210	2.135E-12	4.634E-08
PO211	1.434E-11	4.754E-09
PO212	3.724E-16	6.210E-13
PO214	6.505E-10	2.595E-07
PO215	5.123E-09	1.698E-06
PO216	5.813E-16	9.695E-13
PO218	6.508E-10	2.596E-07
RN219	5.123E-09	1.698E-06
RN220	5.813E-16	9.695E-13
RN222	6.508E-10	2.596E-07
FR223	7.069E-11	2.340E-08
RA223	5.123E-09	1.698E-06
RA224	5.813E-16	9.695E-13
RA226	6.508E-10	2.596E-07
RA228	5.219E-15	1.206E-12
AC227	5.123E-09	1.696E-06
AC228	5.219E-15	1.206E-12
TH227	5.052E-09	1.675E-06
TH228	5.813E-16	9.690E-13
TH230	3.005E-06	6.009E-05
TH231	1.537E-02	1.537E-02
TH232	1.044E-13	2.088E-12
TH234	3.339E-01	3.339E-01
PA231	3.253E-07	6.512E-06
PA234M	3.339E-01	3.339E-01
PA234	4.341E-04	4.341E-04
U234	3.338E-01	3.338E-01
U235	1.537E-02	1.537E-02
U236	2.116E-03	2.116E-03
U238	3.339E-01	3.339E-01
SUMTOT	1.369E+00	1.369E+00

* The data for this Table is taken from Reference 4.

Table 4

U additions /yr to TEEB = 5.70E-04 MTU
effected vol. of TEEB = 7840.8 ft3
= 222.03 m3
soil density = 1.70E+06 g/m3

Curies in TEEB after 1 yr Addition			Concentration in TEEB Clay (Bq/gm); 1 Yr addition		
	Assumed Ingrowth Period			Assumed ingrowth Period	
nuclide	1 yr decay	20 yr decay	nuclide	1 yr decay	20 yr decay
TL207	2.912E-12	9.650E-10	TL207	2.854E-10	9.460E-08
TL208	1.191E-19	1.985E-16	TL208	1.167E-17	1.946E-14
PB210	3.755E-15	2.641E-11	PB210	3.681E-13	2.589E-09
PB211	2.920E-12	9.679E-10	PB211	2.863E-10	9.488E-08
PB212	3.313E-19	5.526E-16	PB212	3.248E-17	5.417E-14
PB214	3.709E-13	1.479E-10	PB214	3.636E-11	1.450E-08
BI210	3.755E-15	2.641E-11	BI210	3.681E-13	2.589E-09
BI211	2.920E-12	9.679E-10	BI211	2.863E-10	9.488E-08
BI212	3.313E-19	5.526E-16	BI212	3.248E-17	5.417E-14
BI214	3.709E-13	1.479E-10	BI214	3.636E-11	1.450E-08
PO210	1.217E-15	2.641E-11	PO210	1.193E-13	2.589E-09
PO211	8.174E-15	2.710E-12	PO211	8.013E-13	2.656E-10
PO212	2.123E-19	3.540E-16	PO212	2.081E-17	3.470E-14
PO214	3.708E-13	1.479E-10	PO214	3.635E-11	1.450E-08
PO215	2.920E-12	9.679E-10	PO215	2.863E-10	9.488E-08
PO216	3.313E-19	5.526E-16	PO216	3.248E-17	5.417E-14
PO218	3.710E-13	1.480E-10	PO218	3.636E-11	1.451E-08
RN219	2.920E-12	9.679E-10	RN219	2.863E-10	9.488E-08
RN220	3.313E-19	5.526E-16	RN220	3.248E-17	5.417E-14
RN222	3.710E-13	1.480E-10	RN222	3.636E-11	1.451E-08
FR223	4.029E-14	1.334E-11	FR223	3.950E-12	1.307E-09
RA223	2.920E-12	9.679E-10	RA223	2.863E-10	9.488E-08
RA224	3.313E-19	5.526E-16	RA224	3.248E-17	5.417E-14
RA226	3.710E-13	1.480E-10	RA226	3.636E-11	1.451E-08
RA228	2.975E-18	6.874E-16	RA228	2.916E-16	6.739E-14
AC227	2.920E-12	9.667E-10	AC227	2.863E-10	9.477E-08
AC228	2.975E-18	6.874E-16	AC228	2.916E-16	6.739E-14
TH227	2.880E-12	9.548E-10	TH227	2.823E-10	9.359E-08
TH228	3.313E-19	5.523E-16	TH228	3.248E-17	5.414E-14
TH230	1.713E-09	3.425E-08	TH230	1.679E-07	3.358E-06
TH231	8.761E-06	8.761E-06	TH231	8.588E-04	8.588E-04
TH232	5.951E-17	1.190E-15	TH232	5.833E-15	1.167E-13
TH234	1.903E-04	1.903E-04	TH234	1.866E-02	1.866E-02
PA231	1.854E-10	3.712E-09	PA231	1.818E-08	3.639E-07
PA234M	1.903E-04	1.903E-04	PA234M	1.866E-02	1.866E-02
PA234	2.474E-07	2.474E-07	PA234	2.426E-05	2.426E-05
U234	1.903E-04	1.903E-04	U234	1.865E-02	1.865E-02
U235	8.761E-06	8.761E-06	U235	8.588E-04	8.588E-04
U236	1.206E-06	1.206E-06	U236	1.182E-04	1.182E-04
U238	1.903E-04	1.903E-04	U238	1.866E-02	1.866E-02
SUMTOT	7.802E-04	7.803E-04	SUMTOT	7.648E-02	7.649E-02

Note: the sum totals for the comparison of the 1 year vs 20 year in-growth of progeny show the same result indicating that by 1 year an equilibrium condition has been effectively reached.

Table 5
Energy emitted per nuclear transformation (Mev/nt)
From FGR 12, Table A.1.

	Alpha	electron	photon
TL207		0.493	0.002
TL208		0.598	3.375
PB210		0.038	0.005
PB211		0.456	0.051
PB212		0.176	0.148
PB214		0.293	0.25
BI210		0.389	
BI211	6.55	0.01	0.047
BI212	2.174	0.472	0.186
BI214		0.659	1.508
PO210	5.297		
PO211	7.442		0.008
PO212	8.785		
PO214	7.687		
PO215	7.386		
PO216	6.779		
PO218	6.001		
RN219	6.757	0.006	0.056
RN220	6.288		
RN222	5.489		
FR223		0.4	0.059
RA223	5.667	0.076	0.134
RA224	5.674	0.002	0.01
RA226	4.774	0.004	0.007
RA228		0.017	
AC227	0.068	0.016	
AC228		0.475	0.971
TH227	5.884	0.053	0.11
TH228	5.4	0.021	0.003
TH230	4.671	0.015	0.002
TH231		0.165	0.026
TH232	3.996	0.012	0.001
TH234		0.06	0.009
PA231	4.969	0.065	0.048
PA234M		0.822	0.012
PA234		0.494	1.919
U234	4.758	0.013	0.002
U235	4.396	0.049	0.156
U236	4.505	0.011	0.002
U238	4.187	0.01	0.001

Data taken from Reference 2

Table 6
Total Absorbed Dose (Rad/yr) for Semi-infinate Source
1 Yr Addition to TEEB/w 1 yr decay ingrowth assumed

	Alpha Rad/yr	electron rad/yr	photon rad/yr	Total rad/yr
TL207	0.000E+00	3.557E-11	1.443E-13	3.572E-11
TL208	0.000E+00	1.765E-18	9.959E-18	1.172E-17
PB210	0.000E+00	3.536E-15	4.652E-16	4.001E-15
PB211	0.000E+00	3.300E-11	3.691E-12	3.669E-11
PB212	0.000E+00	1.445E-18	1.215E-18	2.660E-18
PB214	0.000E+00	2.693E-12	2.298E-12	4.991E-12
BI210	0.000E+00	3.619E-14	0.000E+00	3.619E-14
BI211	4.740E-10	7.236E-13	3.401E-12	4.781E-10
BI212	1.785E-17	3.876E-18	1.527E-18	2.325E-17
BI214	0.000E+00	6.057E-12	1.386E-11	1.992E-11
PO210	1.597E-13	0.000E+00	0.000E+00	1.597E-13
PO211	1.507E-12	0.000E+00	1.620E-15	1.509E-12
PO212	4.621E-17	0.000E+00	0.000E+00	4.621E-17
PO214	7.063E-11	0.000E+00	0.000E+00	7.063E-11
PO215	5.345E-10	0.000E+00	0.000E+00	5.345E-10
PO216	5.566E-17	0.000E+00	0.000E+00	5.566E-17
PO218	5.517E-11	0.000E+00	0.000E+00	5.517E-11
RN219	4.890E-10	4.342E-13	4.052E-12	4.935E-10
RN220	5.163E-17	0.000E+00	0.000E+00	5.163E-17
RN222	5.046E-11	0.000E+00	0.000E+00	5.046E-11
FR223	0.000E+00	3.994E-13	5.891E-14	4.583E-13
RA223	4.101E-10	5.500E-12	9.697E-12	4.253E-10
RA224	4.659E-17	1.642E-20	8.211E-20	4.669E-17
RA226	4.389E-11	3.677E-14	6.435E-14	4.399E-11
RA228	0.000E+00	1.253E-18	0.000E+00	1.253E-18
AC227	4.921E-12	1.158E-12	0.000E+00	6.079E-12
AC228	0.000E+00	3.502E-17	7.158E-17	1.066E-16
TH227	4.199E-10	3.782E-12	7.850E-12	4.315E-10
TH228	4.434E-17	1.724E-19	2.463E-20	4.454E-17
TH230	1.983E-07	6.367E-10	8.489E-11	1.990E-07
TH231	0.000E+00	3.582E-05	5.645E-06	4.147E-05
TH232	5.893E-15	1.770E-17	1.475E-18	5.912E-15
TH234	0.000E+00	2.830E-04	4.245E-05	3.254E-04
PA231	2.283E-08	2.987E-10	2.206E-10	2.335E-08
PA234M	0.000E+00	3.877E-03	5.660E-05	3.934E-03
PA234	0.000E+00	3.029E-06	1.177E-05	1.480E-05
U234	2.243E-02	6.130E-05	9.430E-06	2.250E-02
U235	9.544E-04	1.064E-05	3.387E-05	9.989E-04
U236	1.347E-04	3.288E-07	5.978E-08	1.350E-04
U238	1.975E-02	4.716E-05	4.716E-06	1.980E-02
total =	4.327E-02	4.318E-03	1.645E-04	4.775E-02

Table 7
Total Absorbed Dose (Rad/yr) for Semi-infinate Source
1 Yr Addition to TEEB/w 20 yr decay ingrowth assumed

	Alpha rad/yr	electron rad/yr	photon rad/yr	Total rad/yr
TL207	0.000E+00	1.179E-08	4.783E-11	1.184E-08
TL208	0.000E+00	2.942E-15	1.660E-14	1.955E-14
PB210	0.000E+00	2.487E-11	3.272E-12	2.814E-11
PB211	0.000E+00	1.094E-08	1.223E-09	1.216E-08
PB212	0.000E+00	2.410E-15	2.027E-15	4.437E-15
PB214	0.000E+00	1.074E-09	9.164E-10	1.990E-09
BI210	0.000E+00	2.546E-10	0.000E+00	2.546E-10
BI211	1.571E-07	2.398E-10	1.127E-09	1.585E-07
BI212	2.977E-14	6.464E-15	2.547E-15	3.878E-14
BI214	0.000E+00	2.416E-09	5.528E-09	7.943E-09
PO210	3.467E-09	0.000E+00	0.000E+00	3.467E-09
PO211	4.997E-10	0.000E+00	5.372E-13	5.003E-10
PO212	7.706E-14	0.000E+00	0.000E+00	7.706E-14
PO214	2.818E-08	0.000E+00	0.000E+00	2.818E-08
PO215	1.772E-07	0.000E+00	0.000E+00	1.772E-07
PO216	9.284E-14	0.000E+00	0.000E+00	9.284E-14
PO218	2.201E-08	0.000E+00	0.000E+00	2.201E-08
RN219	1.621E-07	1.439E-10	1.343E-09	1.636E-07
RN220	8.611E-14	0.000E+00	0.000E+00	8.611E-14
RN222	2.013E-08	0.000E+00	0.000E+00	2.013E-08
FR223	0.000E+00	1.322E-10	1.950E-11	1.517E-10
RA223	1.359E-07	1.823E-09	3.214E-09	1.410E-07
RA224	7.770E-14	2.739E-17	1.369E-16	7.787E-14
RA226	1.751E-08	1.467E-11	2.567E-11	1.755E-08
RA228	0.000E+00	2.896E-16	0.000E+00	2.896E-16
AC227	1.629E-09	3.833E-10	0.000E+00	2.012E-09
AC228	0.000E+00	8.092E-15	1.654E-14	2.463E-14
TH227	1.392E-07	1.254E-09	2.603E-09	1.431E-07
TH228	7.391E-14	2.874E-16	4.106E-17	7.424E-14
TH230	3.965E-06	1.273E-08	1.698E-09	3.979E-06
TH231	0.000E+00	3.582E-05	5.645E-06	4.147E-05
TH232	1.179E-13	3.539E-16	2.949E-17	1.182E-13
TH234	0.000E+00	2.830E-04	4.245E-05	3.254E-04
PA231	4.571E-07	5.979E-09	4.415E-09	4.675E-07
PA234M	0.000E+00	3.877E-03	5.660E-05	3.934E-03
PA234	0.000E+00	3.029E-06	1.177E-05	1.480E-05
U234	2.243E-02	6.130E-05	9.430E-06	2.250E-02
U235	9.544E-04	1.064E-05	3.387E-05	9.989E-04
U236	1.347E-04	3.288E-07	5.978E-08	1.350E-04
U238	1.975E-02	4.716E-05	4.716E-06	1.980E-02
total =	4.328E-02	4.318E-03	1.646E-04	4.776E-02

Table 8
Integrated Dose (alpha, beta, gamma) to First TEEB Liner
Annual mass (gm) of U (natural) to TEEB = 570
Absorbed Dose Rate (rad/yr) = 4.776E-02

Year	Annual Dose in yr (rad)	Accumulative dose (rad)
1	4.776E-02	4.776E-02
2	9.552E-02	1.433E-01
3	1.433E-01	2.866E-01
4	1.910E-01	4.776E-01
5	2.388E-01	7.164E-01
6	2.866E-01	1.003E+00
7	3.343E-01	1.337E+00
8	3.821E-01	1.719E+00
9	4.298E-01	2.149E+00
10	4.776E-01	2.627E+00
11	5.254E-01	3.152E+00
12	5.731E-01	3.725E+00
13	6.209E-01	4.346E+00
14	6.686E-01	5.015E+00
15	7.164E-01	5.731E+00
16	7.641E-01	6.495E+00
17	8.119E-01	7.307E+00
18	8.597E-01	8.167E+00
19	9.074E-01	9.074E+00
20	9.552E-01	1.003E+01
21	1.003E+00	1.103E+01
22	1.051E+00	1.208E+01
23	1.098E+00	1.318E+01
24	1.146E+00	1.433E+01
25	1.194E+00	1.552E+01
26	1.242E+00	1.676E+01
27	1.289E+00	1.805E+01
28	1.337E+00	1.939E+01
29	1.385E+00	2.078E+01
30	1.433E+00	2.221E+01

Total Rad = 2.221E+01 Integrated Dose from Waste added to TEEB

Table 9
Background Soil Contribution Absorbed Dose Rate to TEEB Liner
from the Uranium Decay Series
[Starting with U-238 = measured Bkg at approx. 182.1 pCi/kg]

	Nuclide Concent.	Rad/year			
Nuclide	pCi/kg	Alpha	electron	photon	total
PB210	182.1	0.000E+00	1.296E-04	1.705E-05	1.467E-04
PB214	182.1	0.000E+00	9.993E-04	8.527E-04	1.852E-03
BI210	182.1	0.000E+00	1.327E-03	0.000E+00	1.327E-03
BI214	182.1	0.000E+00	2.248E-03	5.143E-03	7.391E-03
PO210	182.1	1.807E-02	0.000E+00	0.000E+00	1.807E-02
PO214	182.1	2.622E-02	0.000E+00	0.000E+00	2.622E-02
PO218	182.1	2.047E-02	0.000E+00	0.000E+00	2.047E-02
RN222	182.1	1.872E-02	0.000E+00	0.000E+00	1.872E-02
RA226	182.1	1.628E-02	1.364E-05	2.388E-05	1.632E-02
TH230	182.1	1.593E-02	5.116E-05	6.821E-06	1.599E-02
TH234	182.1	0.000E+00	2.046E-04	3.070E-05	2.353E-04
PA234M	182.1	0.000E+00	2.804E-03	4.093E-05	2.845E-03
PA234	182.1	0.000E+00	1.685E-03	6.545E-03	8.230E-03
U234	182.1	1.623E-02	4.434E-05	6.821E-06	1.628E-02
U238	182.1	1.428E-02	3.411E-05	3.411E-06	1.432E-02
	sum total =	1.462E-01	9.540E-03	1.267E-02	1.684E-01

Integrated 30 year TEEB Liner dose from Uranium Decay Series (Rads) = 5.05

Table 10
Background Soil Contribution Absorbed Dose Rate to TEEB Liner
from the Thorium Decay Series
[Starting with Th-232 = measured Bkg at approx. 187.1 pCi/kg]

	Nuclide Concent.	Rad/year			
Nuclide	pCi/kg	Alpha	electron	photon	total
TL208	187.1	0.000E+00	2.096E-03	1.183E-02	1.392E-02
PB212	187.1	0.000E+00	6.168E-04	5.186E-04	1.135E-03
BI212	187.1	7.619E-03	1.654E-03	6.518E-04	9.924E-03
PO212	187.1	3.079E-02	0.000E+00	0.000E+00	3.079E-02
PO216	187.1	2.376E-02	0.000E+00	0.000E+00	2.376E-02
RN220	187.1	2.204E-02	0.000E+00	0.000E+00	2.204E-02
RA224	187.1	1.988E-02	7.009E-06	3.504E-05	1.993E-02
RA228	187.1	0.000E+00	5.957E-05	0.000E+00	5.957E-05
AC228	187.1	0.000E+00	1.665E-03	3.403E-03	5.067E-03
TH228	187.1	1.892E-02	7.359E-05	1.051E-05	1.901E-02
TH232	187.1	1.400E-02	4.205E-05	3.504E-06	1.405E-02
	sum total =	1.370E-01	6.213E-03	1.645E-02	1.597E-01

Integrated 30 year TEEB Liner dose from Thorium Decay Series (Rads) = 4.79

Table 11
Background Soil Contribution Absorbed Dose Rate to TEEB Liner
from the Actinium Decay Series
[Starting with U-235 = measured Bkg at approx. 8.8 pCi/kg]

	Nuclide Concent.	Rad/year			
Nuclide	pCi/kg	Alpha	electron	photon	total
TL207	8.8	0.000E+00	8.126E-05	3.296E-07	8.159E-05
PB211	8.8	0.000E+00	7.516E-05	8.406E-06	8.357E-05
BI211	8.8	1.080E-03	1.648E-06	7.747E-06	1.089E-03
PO211	8.8	1.227E-03	0.000E+00	1.319E-06	1.228E-03
PO215	8.8	1.217E-03	0.000E+00	0.000E+00	1.217E-03
RN219	8.8	1.114E-03	9.889E-07	9.230E-06	1.124E-03
FR223	8.8	0.000E+00	6.593E-05	9.725E-06	7.565E-05
RA223	8.8	9.341E-04	1.253E-05	2.209E-05	9.687E-04
AC227	8.8	1.121E-05	2.637E-06	0.000E+00	1.385E-05
TH227	8.8	9.698E-04	8.736E-06	1.813E-05	9.967E-04
TH231	8.8	0.000E+00	2.720E-05	4.285E-06	3.148E-05
PA231	8.8	8.190E-04	1.071E-05	7.912E-06	8.376E-04
U235	8.8	7.246E-04	8.076E-06	2.571E-05	7.584E-04
	sum total =	8.096E-03	2.949E-04	1.149E-04	8.506E-03

Integrated 30 year TEEB Liner dose from Actinium Decay Series (Rads) = 0.26

Table 12
Total Absorbed Dose (Rad/yr) for Infinate Source from Soil Background
Other Measured Radionuclides

	Nuclide Concent.	Rad/year			
	pCi/kg	Alpha	electron	photon	total
Cs-137	70.9	0.000E+00	2.576E-03	7.928E-04	3.369E-03
K-40	3892.8	0.000E+00	3.813E-02	1.137E-02	4.951E-02
	sum total =	0.000E+00	4.071E-02	1.217E-02	5.288E-02

Integrated 30 year TEEB Liner dose from Other Measured Nuclides (Rads) = 1.59

The cosmic-ray absorbed dose rate (in air) at 1000 m above MSL = 37 mrad/yr
Integrated 30 year TEEB Liner dose from Cosmic-rays (Rads) = 1.11

Table 13

Total 30 year absorbed dose to the TEEB liner from soil Background & Cosmic-Rays

from the Uranium Decay Series	5.05	Rad
from the Thorium Decay Series	4.79	Rad
from the Actinium Decay Series	0.26	Rad
Other Measured Radionuclides	1.59	Rad
from cosmic-rays	1.11	Rad
Total Bkg Dose	12.79	Rad

6.0 Results / Conclusions:

The depth of soil below the TEEB that would be required to uniformly mix all the 30 year uranic waste discharge to the basin to measured background concentrations in site soils is approximately 16.75 ft. When added to the design depth of clay (3 ft) used to line the TEEB, the total depth from the TEEB surface to the bottom of the soil column is 19.75 ft. This estimate assumes that the entire waste radioactivity is uniformly mixed in a soil column bounded laterally by the surface area of the TEEB (0.72 acres). This estimate assumes no credit for the two liner barriers in the TEEB designed to prevent this vertical movement below the basin.

The 30 year absorbed dose from the annual design quantity of uranic waste discharged to the TEEB is 22.21 Rad. To this is added a 30 year background radiation component from measured site area soil samples and cosmic-ray radiation of 12.79 Rad, giving a total absorbed dose over the period of interest of 35.0 Rad. This total absorbed dose over the 30 year operating period of the liner represents a very small fraction of typical integrated dose thresholds before detectable damage for many type of plastics that typically can range between 1E+4 to 1E+7 Rad (Reference 6).

7.0 References:

1. Letter dated May 20, 2004, from R. Krich to NRC Document Control Desk Director, "Response to NRC Request for Additional Information Regarding the National Enrichment Facility Environmental Report", NEF#04-019.

2. Federal Guidance Report No.12, "External Exposure to Radionuclides in Air, Water, and Soil", EPA-402-R-93-081, K. Eckerman and J Ryman, September 1993.

3. FANP Calculation 32-2400513-00, "Potential Doses Due to Effluent Discharges from the NEF, New Mexico Site", M. Strum, November 21, 2003.

4. FANP Calculation 32-2400524-00, "National Enrichment Facility – New Mexico Site- Activity and Photon Spectra for Natural, Enriched and Depleted Uranium", J Hamawi, October 31, 2003.

5. FANP Calculation 32-2400576-00, "Radiological Environmental Background Characterization Data – NEF Site, New Mexico", M. Strum, November 21, 2003.

6. J. Kircher & R. Bowman, "Effects of Radiation on Materials and Components", Reinhold Publishing Corporation, 1964, Library of Congress Catalog Card Number 64-16977.

7. B. Shleien, "The Health Physics and Radiological Health Handbook", Revised Edition 1992, Published by Scinta, Inc., ISBN 0-917251-005-9, Library of Congress Catalog Card Number 92-60543.

8. Lockwood Greene document # L4-53-56-CALC, "Calculation: Treated Effluent Evaporative Basin Size", Rev. 0, October 30, 2003 (FANP # 32-5036255-01)

9. NCRP Report No. 94, "Exposure of the Population in the United States and Canada from Natural Background Radiation", (Figure 2.4, page 15), December 30, 1987.

Attachment A

Reference 1 (Partial) NEF Letter to NRC dated May 20, 2004, NEF#04-019

NATIONAL
ENRICHMENT
FACILITY

10 CFR 30.6
10 CFR 40.5
10 CFR 70.5

May 20, 2004

NEF#04-019

ATTN: Document Control Desk
Director
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Louisiana Energy Services, L. P.
National Enrichment Facility
NRC Docket No. 70-3103

Subject: Response to NRC Request for Additional Information Regarding the National Enrichment Facility Environmental Report

References:

1. Letter NEF#03-003 dated December 12, 2003, from E. J. Ferland (Louisiana Energy Services, L. P.) to Directors, Office of Nuclear Material Safety and Safeguards and the Division of Facilities and Security (NRC) regarding "Applications for a Material License Under 10 CFR 70, Domestic licensing of special nuclear material, 10 CFR 40, Domestic licensing of source material, and 10 CFR 30, Rules of general applicability to domestic licensing of byproduct material, and for a Facility Clearance Under 10 CFR 95, Facility security clearance and safeguarding of national security information and restricted data"

2. Letter NEF#04-002 dated February 27, 2004, from R. M. Krich (Louisiana Energy Services, L. P.) to Director, Office of Nuclear Material Safety and Safeguards (NRC) regarding "Revision 1 to Applications for a Material License Under 10 CFR 70, "Domestic licensing of special nuclear material," 10 CFR 40, "Domestic licensing of source material," and 10 CFR 30, "Rules of general applicability to domestic licensing of byproduct material"

3. Letter dated April 29, 2004, from M. Wong (NRC) to R. Krich (Louisiana Energy Services) regarding "Request for Additional Information Related to the Preparation Of An Environmental Impact Statement For The Louisiana Energy Services Proposed National Enrichment Facility"

By letter dated December 12, 2003 (Reference 1), E. J. Ferland of Louisiana Energy Services (LES), L. P., submitted to the NRC applications for the licenses necessary to authorize construction and operation of a gas centrifuge uranium enrichment facility. Revision 1 to these applications was submitted to the NRC by letter dated February 27, 2004 (Reference 2). By letter dated April 29, 2004 (Reference 3), the NRC requested additional information and

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clarifications regarding the Environmental Report be provided within 15 working days (i.e., by May 20, 2004).

The Reference 3 letter includes the NRC Request for Additional Information (RAI) covering the National Enrichment Facility (NEF) Environmental Report (ER). This letter transmits the LES responses to these requests.

Enclosure 1 to this letter provides a compact disc (CD-ROM) containing an electronic version of the LES responses and associated tables and figures referenced in the various responses as requested in the Reference 3 letter.

Enclosure 2 to this letter provides a CD-ROM containing a sample calculation to allow the NRC to reproduce the site score results in ER Section 2.1.3.3, XOQDOQ model input files used to generate the air quality impact data from the proposed NEF operation in ER Section 4.6.2.3, and meteorological data supplied by Waste Control Specialists as requested in RAI 2-7A, RAI 4-4A, and RAI 4-11A, respectively.

Attachment 1 to this letter provides the RAIs with the associated LES response.

Attachment 2 to this letter provides Tables referenced in various RAI responses.

Attachment 3 to this letter provides Figures referenced in various RAI responses.

Attachment 4 to this letter provides a copy of a letter dated March 12, 2004, from J. Mace (US Army Corps of Engineers) to G. Harper (Framatome-ANP) regarding the absence of Corps of Engineers' jurisdictional waters on the NEF site.

Attachment 5 to this letter provides a copy of a letter dated April 13, 2004, from R. Krich (Louisiana Energy Services, L.P.) to J. Parker (New Mexico Environment Department) regarding "Registration of X-Ray Radiation Machines for the National Enrichment Facility."

Attachment 6 to this letter provides documents requested in various RAIs.

If you have any questions, please contact me at 630-657-2813.

Respectfully,

Daniel D. Green for

R. M. Krich
Vice President – Licensing, Safety, and Nuclear Engineering

ATTACHMENT 1

Louisiana Energy Services
Response to April 29, 2004,
Request for Additional Information

2-3 **Treated Effluent Evaporative Basin (TEEB):**

A. Provide specific information on the materials and construction methods to be used for the double-lined TEEB.

- Section 4.4.7 describes controls of impacts to water quality including the TEEB which is double-lined with leak detection equipment installed and open to allow evaporation.

B. Describe the methodology used to determine that the basin liner(s) would last the entire life of the proposed NEF.

C. Describe the proposed monitoring system used to determine whether the liner(s) has been breached. Provide specific information on the equipment and its alarm activation and operation system.

D. Describe the proposed mitigating actions to be implemented if the liner(s) fails.

E. Provide the process for decommissioning the TEEB and disposing of the soil and sludge as low-level waste.

- Based on Section 2.1.2.3.4, the TEEB soil/sludge would contain a complexing agent (citrate), Uranium, and other decay product radionuclides from the 30 years of operation.

F. Identify the treatment method(s) used to treat the citrate in the liquid effluent prior to discharging it into the TEEB.

G. Verify that the amount of chelating agent (i.e., citric acid) in the TEEB's soil/sludge would be acceptable for low-level waste disposal.

LES Response

A. Materials and construction methods to be used for the double-lined Treated Effluent Evaporative Basin (TEEB) will be in compliance with current New Mexico Environment Department (NMED) Guidelines for Liner Material and Site Preparation for Synthetically-Lined Lagoons, December 1995.

The TEEB will have two, geosynthetic fabric liners. The geosynthetic liner material will be chemically compatible with potential liquid effluents to be discharged to the TEEB, resistant to sunlight deterioration, and of sufficient thickness to have adequate tensile strength and tear and puncture resistance. The liner material will be selected during final design and may consist of high-density polyethylene (HDPE) or ethylene interpolymer alloy (Coolgard® XR-5® or Ultra Tech®).

Methods that will be used to construct the TEEB, from the bottom up, are as follows.

- A minimum 0.61-meter (2-foot) thick layer of on-site clay-type soils, free from rock, and compacted at optimum moisture content to 95% of Standard Effort, i.e., American Standard for Testing and Materials (ASTM) D698, "Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

(12,400ft-lbf/ft^3 (600kN-m/m^3))." (applicable version at time of design) will be prepared. The plastic limit of the clay will be approximately 20 and the material will be compacted to +3% of its optimum moisture content.

- A geosynthetic fabric liner will be installed on top of the prepared soil layer. This will serve as the secondary (lower) liner.
- Leak collection piping and associated sump and pumping system, to pump any leakage back to the TEEB, will then be placed.
- A geomembrane drainage mat with the imbedded leak collection piping will be added.
- The primary (upper) geosynthetic fabric liner will be installed.
- The primary liner will then be covered by a minimum 0.3-meter (1-foot) thick prepared layer of on-site clay, free of rock, and compacted at optimum moisture content.
- Liner installation will be by manufacturer certified installers and will be installed and tested according to project specifications.

In addition, the TEEB will be enclosed with animal-friendly fencing to prevent wildlife and unauthorized personnel access. It will also be covered by surface netting or other suitable devices, to exclude waterfowl access to basin water.

B. The methodology that will be used to determine that the basin liner(s) will last the entire life of the proposed NEF is as follows:

- A geosynthetic fabric liner determined to be chemically compatible with basin contents will be selected. The selection process will include consultation with liner manufacturers. This will occur during final design.
- The selected liner will have a projected service life in excess of the projected life of NEF.
- Liner thickness will comply with current NMED Guidelines for Liner Material and Site Preparation for Synthetically-Lined Lagoons, December 1995 and with the recommendations of the liner manufacturer.
- Liner material will be ultraviolet resistant and covered by a minimum of 0.3-meter (1-foot) thick prepared layer of on-site clay, free of rock, and compacted at optimum moisture content.
- The liner material will be pre-approved by a professional engineer and the NMED, as required by current NMED Guidelines for Liner Material and Site Preparation for Synthetically-Lined Lagoons, December 1995.
- Site preparation for basin construction will meet or exceed current NMED Guidelines for Liner Material and Site Preparation for Synthetically-Lined Lagoons, December 1995.

Table ER RAI 3-1A.2 Radiological Chemical Analyses of NEF Site Soil

	Analytical Results Bq/kg (pCi/kg)								Comparative Soil Concentration Bq/kg (pCi/kg) (From ER Section 3.11.1.1)
Sample No. / Nuclide[1]	SS-2	SS-6	SS-9	SS-11	SS-12	SS-13	SS-15	SS-16	
AcTh-228	6.7 (181)	5.6 (151)	6.2 (168)	6.5 (175)	7.6 (205)	6.4 (172)	5.8 (156)	7.4 (201)	8.1 (218)[2]
Cs-137	4.3 (115.5)	3 (80.7)	3.1 (84)	3.1 (83.5)	2.1 (57.6)	1.2 (32.6)	2.7 (74)	3.3 (89.9)	2.82 (76.3)[3]
K-40	137.8 (3720)	140 (3780)	135.2 (3650)	138.9 (3750)	133.7 (3610)	135.6 (3660)	143 (3860)	139.6 (3770)	130 (3,500)[2]
Th-228	5.4 (146)	7.7 (207)	5.7 (154)	6.5 (175)	7.7 (207)	7.4 (199)	7.8 (211)	7.4 (200)	8.1 (218)[2]
Th-230	5.8 (157)	5.0 (130)	5.9 (160)	5.7 (155)	6 (163)	5.5 (149)	6 (161)	6.8 (183)	NA[4]
Th-232	7.6 (204)	6 (163)	6.1 (164)	6.7 (181)	7.3 (196)	7.2 (194)	7.7 (207)	7 (188)	8.1 (218)[2]
U-234	5.9 (159.2)	6.1 (165)	6.2 (168.4)	6.1 (165.4)	5.9 (159.4)	5.3 (143)	6.0 (161.5)	6.1 (165.4)	12 (333)[2]
U-235	0.24 (6.6)	0.25 (6.7)	0.39 (10.6)	0.43 (11.6)	0.41 (11.1)	0.36 (9.7)	0.28 (7.5)	0.24 (6.4)	NA[4]
U-238	5.4 (146.8)	5.9 (158)	6 (161.2)	6.2 (168.5)	6 (162.5)	5.8 (157.6)	5.8 (156.4)	5.7 (152.8)	12 (333)[2]

Notes:
1. No other nuclides were detected above their laboratory measured MDC.
2. Typical lower end range value.
3. Average in NEF site soils. Credited to past weapons testing fallout.
4. Typical soil concentration data is not available.