Long
Island
Power
Authority

Shoreham Nuclear Power Station
P.O. Box 628
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Wading River, N.Y. 11792

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LSNRC-2179

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Shoreham Decommission Project
Application of Soil Release Criteria to Other Bulk Material;
Analysis of Reconcentration Potential and
Possible Exposure Pathways
Shoreham Nuclear Power Station - Unit 1
Docket No. 50-322

Ref: (1) Long Island Power Authority letter LSNRC-2133, dated January 10, 1994; subject: Termination Survey Plan - Revision 2

(2) U.S. Nuclear Regulatory Commission letter dated December 16, 1993, Clayton L. Pittiglio, Jr. (NRC/NMSS) to L. M. Hill (LIPA); subject: Review and Comments of Termination Survey Plan

(3) U.S. Nuclear Regulatory Commission letter dated July 18, 1994, Clayton L. Pittiglio, Jr. (NRC/NMSS) to A. J. Bortz (LIPA); subject: Review of the Shoreham Decommissioning Project Termination Survey Plan, Revision 2, Section 3.1

(4) U.S. Nuclear Regulatory Commission, "Draft Proposed Rule on Radiological Criteria for Decommissioning", SECY-94-150, May 31, 1994.

Ladies and Gentlemen:

The Long Island Power Authority (LIPA) proposed that the release criterion for soil be applied to certain other bulk materials which will remain at the Shoreham facility upon completion of decommissioning. This proposal was first outlined in the second revision of the Shoreham Decommissioning Project Termination Survey Plan (Reference 1) wherein LIPA described the application of the 8 pCi/gm criterion to materials (concrete rubble, sewage sludge, tank bottoms and sediments, and bulk charcoal) other than soil. The unrestricted use limit of 8 pCi/gm for residual Co-60 in soil was specified by the NRC in Reference 2 and reiterated in Reference 3. LIPA proposed the application of this release criterion to these materials principally because other release criteria limits (e.g., surface contamination and gamma exposure rate guidelines) are not readily applicable given the volumetric nature of the residual contamination in the materials. The NRC requested additional information (Reference 3) in order to evaluate LIPA's proposal. Specifically, the NRC stated that an additional evaluation of the potential for Co-60 in the various materials to be reconcentrated through recycling or incineration was necessary. The NRC also recommended that an analysis of potential exposure pathways be included in the evaluation.

LIPA has completed an exposure pathway analysis, forwarded as Enclosure 1 to this letter. The analysis was based on the peak concentration of radionuclides in the specific bulk materials found at the Shoreham facility. The attached dose pathway analysis results show a calculated Total Effective Dose Equivalent (TEDE) of 9.3 mrem per year from the combined effect of all four materials under consideration. This annualized dose compares favorably to the dose limit of 15 mrem/year TEDE for residual radioactivity mentioned in the draft proposed rule on "Radiological Criteria for Decommissioning" (Reference 4). The analysis provided in the enclosure also describes the expected impact of reprocessing the materials, and concludes that in all cases the resultant dose would be no higher than that calculated for the materials in their present locations. These materials are also subject to other appropriate survey requirements of the Shoreham Termination Survey Plan, including measurements for total surface activity, removable surface activity and gamma exposure rate determinations.

Please do not hesitate to contact me if there are additional questions or if further information is required in this matter.

Very truly yours,

J Petrelaw for AB

A. J. Bortz
Resident Manager

Enclosures: (1) Analysis of Bulk Material Reconcentration Potential and Possible Exposure Pathways

cc: L. Bell
C. L. Pittiglio
T. T. Martin
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Mr. Robert Bernero, Director
Office of Nuclear Material Safety and Safeguards

LSNRC -2179

ENCLOSURE 1

Analysis of Bulk Material Reconcentration
Potential and Possible Exposure Pathways

Analysis of Bulk Material Reconcentration Potential and Possible Exposure Pathways

An analysis of the reconcentration potential and possible exposure pathways was performed for the bulk materials (other than soil) at the Shoreham site. The specific bulk materials were: (1) contaminated concrete rubble generated by removal of certain internal walls of the Radwaste Building; (2) contaminated charcoal which was utilized as part of the gaseous radwaste treatment system; (3) contaminated sewage sludge; and (4) contaminated silt and/or biological material in the facility radwaste discharge tunnel. The suitability of allowing for the unrestricted release of a site containing these materials is addressed individually by conservative dose pathway analyses which are based on the peak activity concentration findings reported in the applicable Termination Survey Unit Release Record. The survey unit release records which report results for the above materials include:

SU020, Sanitary Sewage (sewage sludge)

RW059, Condensate Demineralizer Filters Corridor (concrete rubble)
RW060, "A - H" Condensate Demineralizer Room (concrete rubble)

SU044, Radwaste Offgas (contaminated charcoal)

SU045, Circulating Water (silt and biological material)

The results of dose pathway analyses are provided in Attachments 1 through 4 and summarized in Table 1. The summary table also includes a comparison to the Draft NRC Criteria for Decommissioning, namely 15 mrem/yr. The pathway analyses presented are all based on the residential use scenario developed for NUREG/CR-5512. These analyses are highly conservative and include assumptions which envelope the effect of potential reconcentration of radionuclides within the materials. The major component exposure pathways analyzed for each material include direct external exposure to the volumetric source, inhalation of airborne material, and ingestion of contaminated foods. As shown in Table 1, the exposures from each of the additional materials are all less than the NRC Draft Guidance value of 15 mrem/yr, ranging from 0.0013 mrem per year for charcoal to 7.85 mrem per year due to silt in the discharge tunnel. The combined dose for all four additional materials is 9.3 mrem per year.

The conservative nature of these exposure estimates, again which use the generic residential use scenario of NUREG/CR-5512, can be readily seen by comparison to dose assessments performed in a manner similar to the NRC-generated "Generic Dose Assessment For Disposal of Incinerator Ash in a Landfill", dated January, 1994. As listed in Table 1, the maximum public dose impact as determined by a RESRAD analysis for the combined four additional bulk materials are 0.68 mrem per year vs. 9.3 mrem yr. based on the NUREG/CR-5512 scenario.

Each of the attachments (1 through 4) also provide an estimate of the reconcentration effects necessary to raise projected pathway doses to a value equivalent to the NRC Draft Guidance value of 15 mrem/yr. These reconcentration factors range from 1.91 to 11,200. Evaluation of the impact of reconcentration of these small amounts of radioactive material in the specific bulk materials listed above is based primarily upon a review of two NRC documents. The first is NUREG/CR-5814, "Evaluation of Exposure Pathways to Man from Disposal of Radioactive Materials Into Sanitary Sewer Systems", and the second document is the NRC-generated "Generic Dose Assessment For Disposal of Incinerator Ash in a Landfill", dated January, 1994. The first reference states that a volume reduction of sewage sludge as a result of incineration is 95%, or providing a reconcentration ratio of 20:1. The second reference assumes that for one generator, the dilution of incinerator ash by mixing with soil would provide a dilution ratio of 1:50. Thus, a disposal scenario for the bulk materials of concern which involves incineration and disposal of the ash by mixing with soil, as might be hypothesized for disposal of the sewage sludge, silt, or charcoal, would result in a net dilution ratio of 1:2.5, or a dilution factor of 0.4. By comparing this factor to the reconcentration factors for Shoreham specific materials, it is apparent that disposal of the bulk materials represents a minimal dose effect.

Direct recycling of these materials (e.g., use of the sludge as fertilizer, use of the silt as fill or surface overlay, or reuse of the charcoal in various products) without incineration would likely result in the dispersion of the radionuclides, or at least no reconcentration, as there are no other volume reduction processes which would typically be applied to the sludge, silt or charcoal. The concrete rubble must be regarded as at least the equal of soil in terms of the lack of potential for reconcentration of contaminating radionuclides. Concrete rubble is rarely processed for volume reduction. It is much more credible to assume that the rubble would be used as fill material, where it would retain its essential volume and content except for minor surface wear during handling and placement. Thus in all probable disposal scenarios of these various materials, the dose estimate would be equal to or less than the doses provided in Table 1.

As a further analysis, Section 8.1 of the generic dose assessment for the disposal of incinerator ash states that only certain radionuclides which are potentially in incinerator ash may represent significant radiological risks to the public and may approach the public dose limits of 10 CFR 20.301, based on the assumptions made in that generic assessment. The radionuclides found in the bulk materials at Shoreham, which are predominantly Co-60, but also include Cs-137, Zn-65, and Mn-54, are not among the suspect nuclides of the generic assessment. These suspect nuclides include C-14, Cl-36, Tl-204, Ag-208m, Al-26, Tc-99, Nb-94, H-3, I-129, P-32, S-35, Tc-99m, Fe-59, and Ca-45 depending upon disposal and exposure characteristics. The generic assessment recommends that for other than these suspect nuclides, disposal be based on meeting the concentrations given in 10 CFR Part 20, Appendix B, Table II, Column 2 by converting μCi/ml to μCi/gm and assuming 1 ml of water is equivalent to 1 gm of ash. In applying the Appendix B values for

REFERENCES

(For Attachments 1 through 4)

1) LIPA Memorandum NLR 94-0146 dated July 13, 1994; NRC Exit Meeting Record

2) USNRC letter dated July 18, 1994; subject: Review of the Shoreham Decommissioning Project Termination Survey Plan, Revision, 2, Section 3.1

3) Shoreham Decommissioning Project Termination Survey Release Record Report for Survey Unit SU020 - Sanitary Sewage; Termination Survey Final Report, Phase I

4) Shoreham Decommissioning Project Termination Survey Release Record Report for Survey Unit SU059 - "A - H" Condensate Demineralizers Room; Termination Survey Final Report, Phase III

5) Shoreham Decommissioning Project Termination Survey Release Record Report for Survey Unit SU060 - Condensate Demineralizer Filters Corridor; Termination Survey Final Report, Phase III

6) Shoreham Decommissioning Project Termination Survey Release Record Report for Survey Unit SU044 - Radwaste Off-Gas System; Termination Survey Final Report, Phase III

7) Shoreham Decommissioning Project Termination Survey Release Record Report for Survey Unit SU045 - Circulating Water System; Termination Survey Final Report, Phase IV

8) NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning"; Pacific Northwest Laboratory - Final Report, October 1992 - Volume 1

9) NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning"; Pacific Northwest Laboratory - Draft Report, January 1990

10) LILCO Calculation NO. CCI-039221, "Pathway and TEDE Doses for Shoreham Post-Decommissioning Dose Pathway Analysis", Rev. 0 - 3/6/92

11) Shoreham Nuclear Power Station Post-Decommissioning Dose Pathway Analysis Report Draft Report, November 1991

12) USNRC Report "Generic Dose Assessment For Disposal of Incinerator Ash in A Landfill", Draft Report, January 1994

13) NUREG/CR-5814, "Evaluation of Exposure Pathways to Man From Disposal of Radioactive Materials Into Sanitary Sewer Systems", Pacific Northwest Laboratory, May 1992

14) Title 10 Code of Federal Regulations Part 20, Appendix B - Concentrations in Air and Water Above Natural Background, Table II, Column 2

15) LIPA Shoreham Decommissioning Project Termination Survey Plan, Revision 2

16) LIPA Shoreham Nuclear Power Station Offsite Dose Calculation Manual, LIPA Rev. 2

17) USNRC, "Radiological Criteria for Decommissioning of NRC-Licensed Facilities; Enhanced Participatory Rulemaking, Availability of the Staff's Draft of the Rule:, Federal Register, February 2, 1994, 4688 - 4869.

18) USNRC, Draft Proposed Rule on Radiological Criteria for Decommissioning, SECY-94-150, May 31, 1994

multiple nuclides, the sum of the fractions approach is suggested, with the sum to be less than 100%. Table 1 provides the results of such an analysis for each of the four bulk materials. The summation of the MPC fractions from all of the four materials gives 24.86% assuming peak concentration values, and 7.81% using average material concentration values. Similarly, the benchmark values of 8 pCi/gm of Co-60 in soil represents an MPC fraction of 26.67%. Therefore even by this method of analysis, the bulk materials are shown to be less than the benchmark and less than typically accepted limits for disposal.

TABLE 1-BULK MATERIALS DOSE PATHWAY ANALYSIS RESULTS

T.S.U. No.	SU020	RW059 & RW060	SU044	SU045
Bulk Material	Sludge	Concrete	Charcoal	Silt
Radionuclide	Co-60	Co-60	Cs-137	Co-60
Peak Concentration	6.52E-02 pCi/gm	2.19E-01 pCi/gm	3.85E+00 pCi/gm	1.54E+00 pCi/gm
Total Activity	6.17E-01 uCi	2.62E-01 uCi	2.79E+01 uCi	6.95E+01 uCi
Residential Direct Exposure	3.32E-01 mrem/yr	1.12E+00 mrem/yr	1.07E-03 mrem/yr	7.85E+00 mrem/yr
Residential Inhalation Exposure	6.27E-06 mrem/yr	2.11E-05 mrem/yr	5.41E-05 mrem/yr	1.48E-04 mrem/yr
Residential Ingestion Exposure	3.25E-06 mrem/yr	1.09E-05 mrem/yr	2.13E-04 mrem/yr	7.68E-05 mrem/yr
T E D E	3.32E-01 mrem/yr	1.12E+00 mrem/yr	1.34E-03 mrem/yr	7.85E+00 mrem/yr
Percentage of NRC Draft Criteria	2.21%	7.47%	0.009%	52.33%
Percentage of MPC based on Peak Concentration	0.22%	0.73%	19.25%	4.66%
Avg. Concentration	0.22%	0.36%	5.65%	1.58%

Sum of TEDEs for all bulk materials =	9.30E+00 mrem/yr

Sum of MPC fractions for bulk materials using peak concentration =	24.86%
Sum of MPC fractions for bulk materials using avg. concentration =	7.81%

Comparison with Generic Dose Assessment for Incinerator Ash

RESRAD (Public)	3.75E-03 mrem/yr	1.26E-02 mrem/yr	5.74E-01 mrem/yr	8.86E-02 mrem/yr
IMPACTS (Max Ind)	4.27E-02 mrem/yr	1.44E-01 mrem/yr	2.20E-01 mrem/yr	1.01E+00 mrem/yr

Combined sum of RESRAD doses for materials	6.79E-01 mrem/yr

Termination Survey Unit – SU020: SANITARY SEWAGE – [SLUDGE]

LOCATION NUMBER	LOCATION DESCRIPTION	Co-60 [pCi/gm]	Lc (LLD)* [pCi/gm]	>Lc	Lr + [pCi/gm]	>Lr	MASS [gms]	Co-60 [uCi]
1	Ejec. Pump	< LLD	1.86E-02		6			
2	Sump Pump	< LLD	1.11E-02		6			
3	Septic Tank	< LLD	1.64E-02		6			
4	Septic Tank	6.52E-02	4.12E-03	X	6		9.46E+06	6.17E-01
5	Leach Pool	< LLD	1.17E-02		6			
6	Leach Pool	< LLD	1.77E-02		6			
7	Leach Pool	< LLD	1.32E-02		6			
8	Leach Pool	< LLD	9.96E-03		6			
9	Leach Pool	< LLD	1.59E-02		6			
10	Septic Tank	Inaccessible	N/A		N/A			
11	Septic Tank	< LLD	1.37E-02		6			
12	Septic Tank	< LLD	1.59E-02		6			
13	Leach Pool	< LLD	1.86E-02		6			
14	Leach Pool	Inaccessible	N/A		N/A			
9	QC Replicate	< LLD	1.32E-02		6			
Peak Activity Concentration Co-60		6.52E-02 pCi/gm					9.46E+06 gms	6.17E-01 uCi

* Lc represents decay corrected LLD for identified isotope(s).

\+ Lr represents 75% of the release limit (8 pCi/gm) for total activity in soil, sediment, and special samples.

Co-60 : Regulatory Limits / Commitments

Co-60 Activity Concentration Values

SOURCE	LIMIT	REFERENCE
10CFR20 MPC	3E-05 uCi/ml	10 CFR Part 20, App.B, Table II Col.2
TERM SURVEY	8E-06 uCi/gm	TSP Sec.5.2.3 (an NRC Criterion)
ODCM LLD	5E-07 uCi/ml	ODCM Table 4.11.1.1.1-1
REMP LLD	1.5E-08 uCi/ml	ODCM Table 4.12.1-1
	VS.	
SEWAGE	6.52E-08 uCi/gm	SU020 Term Survey Release Record Rpt.
MPC Fraction	0.22%	Peak & Avg.

For determining the suitability of using the soil free-release limit of 8 pCi/gm to other bulk material, the peak activity (6.52E-02 pCi/gm) will be used. LILCO Calculation No. CCI-039221, "Pathway and TEDE Doses for Shoreham Post Decommissioning Dose Pathway Analysis" shows that of the four scenarios, Building Renovation, Building Occupancy, Drinking Water and Residential Use; Residential Use results in the highest TEDE. Furthermore, of the major component pathways for the residential use scenario, External Exposure is the most significant followed by ingestion and inhalation in that order, with groundwater not even being a credible pathway in the case of Shoreham.

Residential Use Scenario

The major component exposure pathways to be considered for this scenario include:

A) Direct External Exposure to Soil Volume Sources;
B) Inhalation of Airborne Materials;
C) Ingestion of Contaminated Food.

Groundwater related exposure pathways are not credible at the Shoreham site for two reasons;

1) This pathway is predicated on the presence of buried contaminated rubble left in place after decommissioning with the contamination allowed to leach into the groundwater where it would be picked up and transported to sources of domestic water supply. There is no buried contaminated rubble currently at the Shoreham site nor does the LIPA Decommissioning Plan allow for any as part of the decommissioning process.

2) Groundwater drainage at the site is north to the Long Island Sound. the three onsite wells which are used for drinking water are located south of the actual plant site and hence, no public or site drinking water supplies could be affected by any site activity.

A) Direct External Exposure to Soil Volume Sources

The fundamental relationship for calculating radiation dose rates to people from any radionuclide in an exposure pathway is given by:

$$R(i,p) = C(i,p) \times U(p) \times D(i,p)$$ [Ref. 9]

Where

R (i,p) = The radiation dose equivalent or committed radiation dose equivalent from radionuclide i via exposure pathway p, in mrem/yr;

C (i,p) = The concentration of radionuclide i in the media of exposure in pathway p, in pCi/gm (Bq/gm) for volume contamination in buildings and soil;
= 6.52E-02 pCi/gm [Ref. 3]

U (p) = The usage parameter (exposure rate) associated with exposure pathway p, in hr/yr for external exposure. For residential scenario, the equivalent number of direct (unshielded) exposure = 1800 hrs outdoors (actually 1700 hrs outdoors + 100 hrs gardening) + 4380 hrs indoors X 0.33 (Home Shielding Factor); [Ref. 8,9]
= 3245 hrs

D (i,p) = The committed effective dose equivalent factor for radionuclide i and exposure pathway p, used to convert the concentration and usage parameters to the committed effective dose equivalent in mrem/hr per pCi/gm.
= 1.57E-03 mrem/hr per pCi/gm for Co-60 [Ref. 8]

Therefore,

R (i,p) = 6.52E-02 pCi/gm X 3245 hrs X 1.57E-03 mrem/hr per pCi/gm
= **3.32E-01 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

B) Inhalation of Airborne Materials

The general equation for estimating the committed effective dose rate equivalent by inhalation received by individuals for radionuclide i is given by:

H (inh,i) = V X t X C (d) X C (w,i) X DF (inh,i) [Ref. 9]

Where

H (inh,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by inhalation, in mrem/yr;

V = The ventilation rate of the individual, in m^3/hr;
= 1.0 [Ref. 8,9]

t = The duration of exposure for the individual, in hr/yr;
= 4380 hrs Indoors + 1700 hrs Outdoors + 100 hrs Gardening [Ref. 8,9]

C (d) = The concentration of respirable dust in air, in gm/m^3;
= Indoors = 5E-05, Outdoors = 1E-04, Gardening = 5E-04 [Ref. 8,9]

C (w,i) = The concentration of radionuclide i in the contaminated material, in pCi/gm;
= 6.52E-02 pCi/gm [Ref. 3]

DF (inh,i) = The committed effective dose from inhalation of radionuclide i, in mrem/pCi.
= 2.19E-04 mrem/pCi for Co-60 [Ref. 8]

Therefore,

H (inh,i) = 1 m^3/hr X (4380*5E-05+1700*1E-04+100*5E-04) hr-gm/yr-m^3 X 6.52E-02 pCi/gm X 2.19E-04 mrem/pCi
= **6.27E-06 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

RESRAD Incinerator Ash Dose (to the public)

Dose = DSR(i,tmax) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm] [Ref. 12]
= 5.75E-02 X 6.52E-02
= **3.75E-03 mrem/yr**

IMPACTS Incinerator Ash Dose (to the max. individual) [Ref. 12]

Dose = DSR(i,trans) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm]
= 6.554E-01 X 6.52E-02
= **4.27E-02 mrem/yr**

C) Ingestion of Contaminated Food

This pathway is based upon the assumption that a certain fraction of food consumed by site residents is grown in the soil onsite which contains residual acyivity concentrations. Assuming the same dietary commitments as NUREG/CR-5512 (25% of total diet as defined in R.G. 1.109) allows one to take the values for specific nuclides directly from NUREG/CR-5512, which are based on 1 pCi/gm concentrations and multiply by the value to be used for soil volume concentrations.

The simplified form of the equation is given by:

H (ing,i) = FD (ing,i) X C (i,p) [Ref. 9]

Where

H (ing,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by ingestion, in mrem/yr;

FD (ing,i) = The food ingestion effective dose equivalent factor for the most sensitive organ for radionuclide i, in mrem/pCi, assuming 1 pCi/gm and the dietary input listed below:

a) 47.5 Kg/yr of vegetable produce,
b) 27.5 L/yr of milk,
c) 19.2 Kg/yr of meat (beef, pork, poultry)
d) 4.8 Kg/yr of eggs. [Ref. 9]

= 4.99E-05 mrem/pCi for Co-60 for LLI wall. (@ 1 pCi/gm soil activity) [Ref. 8]

C (i,p) = The soil volume activity, for radionuclide i, in pCi/gm
= 6.52E-02 pCi/gm for Co-60 [Ref. 3]

Therefore,

H (ing,i) = 4.99E-05 mrem/pCi per pCi/gm X 6.52E-02 pCi/gm
= 3.25E-06 mrem/yr

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

Residential Use Scenario – Total Effective Dose Equivalent

Direct Exposure + Inhalation Exposure + Food Ingestion Exposure

3.32E-01 mrem/yr + 6.27E-06 mrem/yr + 3.25E-06 mrem/yr

TEDE = 3.32E-01 mrem/yr

Reconcentration Factor required to raise projected pathway dose to Draft NRC Criteria Value =

RF = 4.52E+01

Termination Survey Unit – RW059: "A-H" COND. DEMIN. RM. – [CONCRETE]
Termination Survey Unit – RW060: COND. DEMIN. FLTRS COR. – [CONCRETE]

SURVEY POINT	DRUM I.D. NUMBER	Co-60 [pCi/gm]	CONCRETE [gm] *	Co-60 [uCi]
247/248	93-DRM-142	< 1.48E-02		
251/252	93-DRM-148	< 1.36E-02		
253/254	93-DRM-150	< 1.42E-02		
255/256	93-DRM-153	< 1.30E-02		
257/258	93-DRM-154	< 1.13E-02		
259/260	93-DRM-162	< 8.79E-03		
261/262	93-DRM-170	< 1.19E-02		
263/264	93-DRM-171	< 1.28E-02		
265/266	93-DRM-172	< 1.15E-02		
269/270	93-DRM-174	< 9.61E-03		
273/274	93-DRM-139	3.53E-02	4.88E+05	1.72E-02
347/348	94-DRM-191	< 1.45E-02		
353/354	94-DRM-249	< 1.03E-02		
355/356	94-DRM-235	8.18E-02	4.88E+05	4.00E-02
357/358	94-DRM-234	2.19E-01	4.88E+05	1.07E-01
387/388	94-DRM-248	< 1.38E-02		
391/392	"A"	1.07E-01	4.88E+05	5.23E-02
393/394	94-DRM-241	< 1.39E-02		
397/398	"B"	< 1.21E-02		
403/404	94-DRM-189	9.42E-02	4.88E+05	4.60E-02
405/406	"C"	< 1.50E-02		
407/408	94-DRM-261	< 1.09E-02		
411/412	"D"	< 6.02E-03		
415/416	"E"	< 8.69E-03		
	PEAK	2.19E-01 pCi/gm	SUM	2.62E-01 uCi

* Specific volumes not known, typically 65% – 85% full (55 gal. drum). Assume full. Density @ 2.35 gm/cm^3.

Co-60 : Regulatory Limits / Commitments

Co-60 Activity Concentration Values

SOURCE		LIMIT		REFERENCE
10CFR20 MPC		3E-05 uCi/ml		10 CFR Part 20, App.B, Table II Col.2
TERM SURVEY		8E-06 uCi/gm		TSP Sec.5.2.3 (an NRC Criterion)
ODCM LLD		5E-07 uCi/ml		ODCM Table 4.11.1.1.1-1
REMP LLD		1.5E-08 uCi/ml		ODCM Table 4.12.1-1
CONCRETE	Peak	2.19E-07 uCi/gm		RW059&060 Term Survey Release Record Rpts.
	Avg.	1.07E-07 uCi/gm		
MPC Fraction		0.73%	0.36%	Peak | Avg.

For determining the suitability of using the soil free-release limit of 8 pCi/gm to other bulk material, the peak concentration found (2.19E-01 pCi/gm of Co-60) represents the most conservative value and will be used in the dose pathway analysis. LILCO Calculation No. CCI-039221, "Pathway and TEDE Doses for Shoreham Post Decommissioning Dose Pathway Analysis" shows that of the four scenarios, Building Renovation, Building Occupancy, Drinking Water and Residential Use; Residential Use results in the highest TEDE. Furthermore, of the major component pathways for the residential use scenario, External Exposure is the most significant followed by ingestion and inhalation in that order, with groundwater not even being a credible pathway in the case of Shoreham.

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2) Groundwater drainage at the site is north to the Long Island Sound. the three onsite wells which are used for drinking water are located south of the actual plant site and hence, no public or site drinking water supplies could be affected by any site activity.

A) Direct External Exposure to Soil Volume Sources

The fundamental relationship for calculating radiation dose rates to people from any radionuclide in an exposure pathway is given by:

R (i,p) = C (i,p) X U (p) X D (i,p) [Ref. 9]

Where

R (i,p) = The radiation dose equivalent or committed radiation dose equivalent from radionuclide i via exposure pathway p, in mrem/yr;

C (i,p) = The concentration of radionuclide i in the media of exposure in pathway p, in pCi/gm (Bq/gm) for volume contamination in buildings and soil;
= 2.19E-01 pCi/gm [Ref. 4,5]

U (p) = The usage parameter (exposure rate) associated with exposure pathway p, in hr/yr for external exposure. For residential scenario, the equivalent number of direct (unshielded) exposure = 1800 hrs outdoors (actually 1700 hrs outdoors + 100 hrs gardening) + 4380 hrs indoors X 0.33 (Home Shielding Factor); [Ref. 8,9]
= 3245 hrs

D (i,p) = The committed effective dose equivalent factor for radionuclide i and exposure pathway p, used to convert the concentration and usage parameters to the committed effective dose equivalent in mrem/hr per pCi/gm.
= 1.57E-03 mrem/hr per pCi/gm for Co-60 [Ref. 8]

Therefore,

R (i,p) = 2.19E-01 pCi/gm X 3245 hrs X 1.57E-03 mrem/hr per pCi/gm
= **1.12E+00 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

B) Inhalation of Airborne Materials

The general equation for estimating the committed effective dose rate equivalent by inhalation received by individuals for radionuclide i is given by:

H (inh,i) = V X t X C (d) X C (w,i) X DF (inh,i) [Ref. 9]

Where

H (inh,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by inhalation, in mrem/yr;

V = The ventilation rate of the individual, in m^3/hr;
= 1.0 [Ref. 8,9]

t = The duration of exposure for the individual, in hr/yr;
= 4380 hrs Indoors + 1700 hrs Outdoors + 100 hrs Gardening [Ref. 8,9]

C (d) = The concentration of respirable dust in air, in gm/m^3;
= Indoors = 5E-05, Outdoors = 1E-04, Gardening = 5E-04 [Ref. 8,9]

C (w,i) = The concentration of radionuclide i in the contaminated material, in pCi/gm;
= 2.19E-01 pCi/gm [Ref. 4,5]

DF (inh,i) = The committed effective dose from inhalation of radionuclide i, in mrem/pCi.
= 2.19E-04 mrem/pCi for Co-60 [Ref. 8]

Therefore,

H (inh,i) = 1 m^3/hr X (4380*5E-05+1700*1E-04+100*5E-04) hr-gm/yr-m^3 X 2.19E-01 pCi/gm X 2.19E-04 mrem/pCi
= **2.11E-05 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

RESRAD Incinerator Ash Dose (to the public)

Dose = DSR(i,tmax) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm] [Ref. 12]
= 5.75E-02 X 2.19E-01
= **1.26E-02 mrem/yr**

IMPACTS Incinerator Ash Dose (to the max. individual) [Ref. 12]

Dose = DSR(i,trans) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm]
= 6.534E-01 X 2.19E-01
= **1.44E-01 mrem/yr**

C) Ingestion of Contaminated Food

This pathway is based upon the assumption that a certain fraction of food consumed by site residents is grown in the soil onsite which contains residual acyivity concentrations. Assuming the same dietary commitments as NUREG/CR-5512 (25% of total diet as defined in R.G. 1.109) allows one to take the values for specific nuclides directly from NUREG/CR-5512, which are based on 1 pCi/gm concentrations and multiply by the value to be used for soil volume concentrations.

The simplified form of the equation is given by:

H (ing,i) = FD (ing,i) X C (i,p) [Ref. 9]

Where

H (ing,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by ingestion, in mrem/yr;

FD (ing,i) = The food ingestion effective dose equivalent factor for the most sensitive organ for radionuclide i, in mrem/pCi, assuming 1 pCi/gm and the dietary input listed below: [Ref. 9]

a) 47.5 Kg/yr of vegetable produce,
b) 27.5 L/yr of milk,
c) 19.2 Kg/yr of meat (beef, pork, poultry)
d) 4.8 Kg/yr of eggs.

= 4.99E-05 mrem/pCi for Co-60 for LLI wall. (@ 1 pCi/gm soil activity) [Ref. 8]

C (i,p) = The soil volume activity, for radionuclide i, in pCi/gm
= 2.19E-01 pCi/gm for Co-60 [Ref. 4,5]

Therefore,

H (ing,i) = 4.99E-05 mrem/pCi per pCi/gm X 2.19E-01 pCi/gm
= **1.09E-05 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

Residential Use Scenario - Total Effective Dose Equivalent

Direct Exposure + Inhalation Exposure + Food Ingestion Exposure

1.12E+00 mrem/yr + 2.11E-05 mrem/yr + 1.09E-05 mrem/yr

TEDE = 1.12E+00 mrem/yr

Reconcentration Factor required to raise projected pathway dose to Draft NRC Criteria Value =

RF = 1.34E+01

Termination Survey Unit - SU044: RADWASTE OFFGAS - [CHARCOAL]

TANK NO.	CHARCOAL [gms]	Co-60 [pCi/gm]	Mn-54 [pCi/gm]	Zn-65 [pCi/gm]	Cs-134 [pCi/gm]	Cs-137 [pCi/gm]	Cs-137 [uCi]	CHARCOAL [gms]	CHARCOAL [lbs]
-045A	5.10E+05	<0.015	<0.009	<0.026	<0.011	3.850	1.96	5.10E+05	1,125
-045B	5.10E+05	<0.014	<0.010	<0.026	<0.011	3.450	1.76	5.10E+05	1,125
-047A	7.89E+06	<0.029	<0.019	<0.058	<0.019	2.550	20.13	7.89E+06	17,400
-047B	7.89E+06	<0.031	<0.019	<0.053	<0.019	0.472	3.73	7.89E+06	17,400
-047C	7.89E+06	<0.014	<0.008	<0.024	<0.009	<0.008			
-047D	7.89E+06	<0.019	<0.011	<0.034	<0.011	<0.011			
-047E	7.89E+06	<0.019	<0.010	<0.032	<0.012	<0.011			
-048A	7.89E+06	<0.018	<0.014	<0.049	<0.013	0.036	0.28	7.89E+06	17,400
-048B	7.89E+06	<0.014	<0.008	<0.025	<0.009	<0.024			
-048C	7.89E+06	<0.016	<0.009	<0.004	<0.010	<0.009			
-048D	7.89E+06	<0.011	<0.007	<0.027	<0.007	<0.007			
-048E	7.89E+06	<0.008	<0.007	<0.021	<0.005	<0.006			
						SUM	27.86	2.47E+07	54,450

Peak Conc. = 3.85 pCi/gm ; Avg. Conc. = 1.13 pCi/gm

Cs-137 : Regulatory Limits / Commitments

Cs-137 Activity Concentration Values

SOURCE	LIMIT	REFERENCE
10CFR20 MPC	2E-05 uCi/ml	10 CFR Part 20, App.B, Table II Col.2
TERM SURVEY	8E-06 uCi/gm	TSP Sec.5.2.3 (an NRC Criterion)
ODCM LLD	5E-07 uCi/ml	ODCM Table 4.11.1.1.1-1
REMP LLD	1.8E-08 uCi/ml	ODCM Table 4.12.1-1
	VS.	
CHARCOAL	3.85E-06 uCi/gm	Peak - SU044 Term Survey Release Record Rpt.
	1.13E-06 uCi/gm	Avg. - SU044 Term Survey Release Record Rpt.
MPC Fraction	19.25%	Peak
	5.65%	Avg.

For determining the suitability of using the soil free-release limit of 8 pCi/gm to other bulk material, the entire source term (27.86 uCi of Cs-137) will be considered and the Peak Conc. will be used for the dose pathway analysis. Use of the peak concentration (which was found in the smallest tank) will be extremely conservative for the dose pathway analysis. LILCO Calculation No. CCI-039221, "Pathway and TEDE Doses for Shoreham Post Decommissioning Dose Pathway Analysis" shows that of the four scenarios, Building Renovation, Building Occupancy, Drinking Water and Residential Use; Residential Use results in the highest TEDE. Furthermore, of the major component pathways for the residential use scenario, External Exposure is the most significant followed by ingestion and inhalation in that order, with groundwater not even being a credible pathway in the case of Shoreham.

Residential Use Scenario

The major component exposure pathways to be considered for this scenario include:

A) Direct External Exposure to Soil Volume Sources;
B) Inhalation of Airborne Materials;
C) Ingestion of Contaminated Food.

Groundwater related exposure pathways are not credible at the Shoreham site for two reasons;

1) This pathway is predicated on the presence of buried contaminated rubble left in place after decommissioning with the contamination allowed to leach into the groundwater where it would be picked up and transported to sources of domestic water supply. There is no buried contaminated rubble currently at the Shoreham site nor does the LIPA Decommissioning Plan allow for any as part of the decommissioning process.
2) Groundwater drainage at the site is north to the Long Island Sound. the three onsite wells which are used for drinking water are located south of the actual plant site and hence, no public or site drinking water supplies could be affected by any site activity.

A) Direct External Exposure to Soil Volume Sources

The fundamental relationship for calculating radiation dose rates to people from any radionuclide in an exposure pathway is given by:

R (i,p) = C (i,p) X U (p) X D (i,p) [Ref. 9]

Where

R (i,p) = The radiation dose equivalent or committed radiation dose equivalent from radionuclide i, via exposure pathway p, in mrem/yr;

C (i,p) = The concentration of radionuclide i in the media of exposure in pathway p, in pCi/gm (Bg/gm) for volume contamination in buildings and soil;
= 3.85E+00 pCi/gm [Ref. 6]

U (p) = The usage parameter (exposure rate) associated with exposure pathway p, in hr/yr for external exposure. For residential scenario, the equivalent number of direct (unshielded) exposure = 1800 hrs outdoors (actually 1700 hrs outdoors + 100 hrs gardening) + 4380 hrs indoors X 0.33 (Home Shielding Factor); [Ref. 8,9]
= 3245 hrs

D (i,p) = The committed effective dose equivalent factor for radionuclide i and exposure pathway p, used to convert the concentration and usage parameters to the committed effective dose equivalent in mrem/hr per pCi/gm.
= 8.53E-08 mrem/hr per pCi/gm for Cs-137 [Ref. 8]

Therefore,

R (i,p) = 3.85E+00 pCi/gm X 3245 hrs X 8.53E-08 mrem/hr per pCi/gm
= 1.07E-03 mrem/yr

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

B) Inhalation of Airborne Materials

The general equation for estimating the committed effective dose rate equivalent by inhalation received by individuals for radionuclide i is given by:

H (inh,i) = V X t X C (d) X C (w,i) X DF (inh,i) [Ref. 9]

Where

H (inh,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by inhalation, in mrem/yr;

V = The ventilation rate of the individual, in m^3/hr;
= 1.0 [Ref. 8,9]

t = The duration of exposure for the individual, in hr/yr;
= 4380 hrs Indoors + 1700 hrs Outdoors + 100 hrs Gardening [Ref. 8,9]

C (d) = The concentration of respirable dust in air, in gm/m^3;
= Indoors = 5E-05, Outdoors = 1E-04, Gardening = 5E-04 [Ref. 8,9]

C (w,i) = The concentration of radionuclide i in the contaminated material, in pCi/gm;
= 3.85E+00 pCi/gm [Ref. 6]

DF (inh,i) The committed effective dose from inhalation of radionuclide i, in mrem/pCi.
= 3.20E-05 mrem/pCi for Cs-137 [Ref. 8]

Therefore,

H (inh,i) = 1 m^3/hr X (4380*5E-05+1700*1E-04+100*5E-04) hr-gm/yr-m^3 X 3.85E+00 pCi/gm X 3.20E-05 mrem/pCi
= **5.41E-05 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

RESRAD Incinerator Ash Dose (to the public)

Dose = DSR(i,tmax) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm] [Ref. 12]
= 1.49E-01 X 3.85E+00
= **5.74E-01 mrem/yr**

IMPACTS Incinerator Ash Dose (to the max. individual) [Ref. 12]

Dose = DSR(i,trans) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm]
= 5.71E-02 X 3.85E+00
= **2.20E-01 mrem/yr**

C) Ingestion of Contaminated Food

This pathway is based upon the assumption that a certain fraction of food consumed by site residents is grown in the soil onsite which contains residual activity concentrations. Assuming the same dietary commitments as NUREG/CR-5512 (25% of total diet as defined in R.G. 1.109) allows one to take the values for specific nuclides directly from NUREG/CR-5512, which are based on 1 pCi/gm concentrations and multiply by the value to be used for soil volume concentrations.

The simplified form of the equation is given by:

H (ing,i) = FD (ing,i) X C (i,p) [Ref. 9]

Where

H (ing,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by ingestion, in mrem/yr;

FD (ing,i) The food ingestion effective dose equivalent factor for the most sensitive organ for radionuclide i, in mrem/pCi, assuming 1 pCi/gm and the dietary input listed below: [Ref. 9]

a) 47.5 Kg/yr of vegetable produce,
b) 27.5 L/yr of milk,
c) 19.2 Kg/yr of meat (beef, pork, poultry)
d) 4.8 Kg/yr of eggs.

= 5.54E-05 mrem/pCi for Cs-137 for Adrenals. (@ 1 pCi/gm soil activity) [Ref. 8]

C (i,p) = The soil volume activity, for radionuclide i, in pCi/gm
= 3.85E+00 pCi/gm for Cs-137 [Ref. 6]

Therefore,

H (ing,i) = 5.54E-05 mrem/pCi per pCi/gm X 3.85E+00 pCi/gm
= **2.13E-04 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

Residential Use Scenario - Total Effective Dose Equivalent

Direct Exposure + Inhalation Exposure + Food Ingestion Exposure

1.07E-03 mrem/yr + 5.41E-05 mrem/yr + 2.13E-04 mrem/yr

TEDE = 1.34E-03 mrem/yr

Reconcentration Factor required to raise projected pathway dose to Draft NRC Criteria Value =

RF = 1.12E+04

Termination Survey Unit – SU045: CIRCULATING WATER – [SILT]

LOCATION NUMBER	LOCATION DESCRIPTION	Co-60 [pCi/gm]	Cs-137 [pCi/gm]	Mn-54 [pCi/gm]	Zn-65 [pCi/gm]
1	Upstream Top of Weir	1.79E-01	<1.18E-02	1.68E-02	<2.85E-02
2	Downstream Top of Weir	1.26E-01	<1.24E-02	<1.20E-02	<2.81E-02
3	Downstream Wall	1.10E-01	<1.05E-02	<1.18E-02	<2.10E-02
4	Upstream Incline Wall	1.29E+00	2.82E-02	3.30E-02	1.86E-01

Peak activity concentrations as given for Location #4

Silt Volume = 1000 cu.ft.
Silt Density = 1.6 gm/cm^3
Silt Activity = Mass X A.C.
Mass = 4.51E+07 gms
A.C. = 1.54E+00 pCi/gm
Silt Activity = 6.95E+01 uCi

SUM = 1.54E+00 pCi/gm

Co-60 / Cs-137 / Mn-54 / Zn-65 : Regulatory Limits / Commitments

Co-60 / Cs-137 / Mn-54 / Zn-65 Activity Concentration Values

SOURCE		LIMIT			REFERENCE
M P C	Co-60	3E-05 uCi/ml			10 CFR Part 20, App.B, Table II Col.2
	Cs-137	2E-05 uCi/ml			
	Mn-54	1E-04 uCi/ml			
	Zn-65	1E-04 uCi/ml			
TERM SURVEY		8E-06 uCi/gm			TSP Sec.5.2.3 (an NRC Criterion)
ODCM LLD		5E-07 uCi/ml			ODCM Table 4.11.1.1.1-1
REMP LLD	Co-60	1.5E-08 uCi/ml			ODCM Table 4.12.1-1
	Cs-137	1.8E-08 uCi/ml			
	Mn-54	1.5E-08 uCi/ml			
	Zn-65	3.0E-08 uCi/ml			
		VS.			
		Peak Conc	Avg Conc		
SILT	Co-60	1.29E-06	4.26E-07	uCi/gm	SU045 Term Survey Release Record Rpt.
	Cs-137	2.82E-08	1.57E-08	uCi/gm	
	Mn-54	3.30E-08	1.84E-08	uCi/gm	
	Zn-65	1.86E-07	6.59E-08	uCi/gm	
% of MPC	Co-60	4.30%	1.42%		
	Cs-137	0.14%	0.08%		
	Mn-54	0.03%	0.02%		
	Zn-65	0.19%	0.07%		
	SUM	4.66%	1.58%		

For determining the suitability of using the soil free-release limit of 8 pCi/gm to other bulk material, the combined peak source activity (1.54E+00 pCi/gm) will be considered as Co-60. This is not only conservative but also will simplify the dose pathway analysis. LILCO Calculation No. CCI-039221, "Pathway and TEDE Doses for Shoreham Post Decommissioning Dose Pathway Analysis" shows that of the four scenarios, Building Renovation, Building Occupancy, Drinking Water and Residential Use; Residential Use results in the highest TEDE. Furthermore, of the major component pathways for the residential use scenario, External Exposure is the most significant followed by ingestion and inhalation in that order, with groundwater not even being a credible pathway in the case of Shoreham.

Residential Use Scenario

The major component exposure pathways to be considered for this scenario include:

A) Direct External Exposure to Soil Volume Sources;
B) Inhalation of Airborne Materials;
C) Ingestion of Contaminated Food.

Groundwater related exposure pathways are not credible at the Shoreham site for two reasons;

1) This pathway is predicated on the presence of buried contaminated rubble left in place after decommissioning with the contamination allowed to leach into the groundwater where it would be picked up and transported to sources of domestic water supply. There is no buried contaminated rubble currently at the Shoreham site nor does the LIPA Decommissioning Plan allow for any as part of the decommissioning process.
2) Groundwater drainage at the site is north to the Long Island Sound. the three onsite wells which are used for drinking water are located south of the actual plant site and hence, no public or site drinking water supplies could be affected by any site activity.

A) Direct External Exposure to Soil Volume Sources

The fundamental relationship for calculating radiation dose rates to people from any radionuclide in an exposure pathway is given by:

$$R(i,p) = C(i,p) \times U(p) \times D(i,p)$$ [Ref. 9]

Where

R (i,p) = The radiation dose equivalent or committed radiation dose equivalent from radionuclide i via exposure pathway p, in mrem/yr;

C (i,p) = The concentration of radionuclide i in the media of exposure in pathway p, in pCi/gm (Bq/gm) for volume contamination in buildings and soil;
= 1.54E+00 pCi/gm [Ref. 7]

U (p) = The usage parameter (exposure rate) associated with exposure pathway p, in hr/yr for external exposure. For residential scenario, the equivalent number of direct (unshielded) exposure = 1800 hrs outdoors (actually 1700 hrs outdoors + 100 hrs gardening) + 4380 hrs indoors X 0.33 (Home Shielding Factor);
= 3245 hrs [Ref. 8,9]

D (i,p) = The committed effective dose equivalent factor for radionuclide i and exposure pathway p, used to convert the concentration and usage parameters to the committed effective dose equivalent in mrem/hr per pCi/gm.
= 1.57E-03 mrem/hr per pCi/gm for Co-60 [Ref. 8]

Therefore,

R (i,p) = 1.54E+00 pCi/gm X 3245 hrs X 1.57E-03 mrem/hr per pCi/gm
= **7.85E+00 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

B) Inhalation of Airborne Materials

The general equation for estimating the committed effective dose rate equivalent by inhalation received by individuals for radionuclide i is given by:

H (inh,i) = V X t X C (d) X C (w,i) X DF (inh,i) [Ref. 9]

Where

H (inh,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by inhalation, in mrem/yr;

V = The ventilation rate of the individual, in m^3/hr;
= 1.0 [Ref. 8,9]

t = The duration of exposure for the individual, in hr/yr;
= 4380 hrs Indoors + 1700 hrs Outdoors + 100 hrs Gardening [Ref. 8,9]

C (d) = The concentration of respirable dust in air, in gm/m^3;
= Indoors = 5E-05, Outdoors = 1E-04, Gardening = 5E-04 [Ref. 8,9]

C (w,i) = The concentration of radionuclide i in the contaminated material, in pCi/gm;
= 1.54E+00 pCi/gm [Ref. 7]

DF (inh,i) = The committed effective dose from inhalation of radionuclide i, in mrem/pCi.
= 2.19E-04 mrem/pCi for Co-60 [Ref. 8]

Therefore,

H (inh,i) = 1 m^3/hr X (4380*5E-05+1700*1E-04+100*5E-04) hr-gm/yr-m^3 X 1.54E+00 pCi/gm X 2.19E-04 mrem/pCi
= **1.48E-04 mrem/yr**

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

RESRAD Incinerator Ash Dose (to the public)

Dose = DSR(i,tmax) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm] [Ref. 12]
= 5.75E-02 X 1.54E+00
= **8.86E-02 mrem/yr**

IMPACTS Incinerator Ash Dose (to the max. individual) [Ref. 12]

Dose = DSR(i,trans) [mrem/yr per pCi/gm] X Peak Concentration [pCi/gm]
= 6.554E-01 X 1.54E+00
= **1.01E+00 mrem/yr**

C) Ingestion of Contaminated Food

This pathway is based upon the assumption that a certain fraction of food consumed by site residents is grown in the soil onsite which contains residual acyivity concentrations. Assuming the same dietary commitments as NUREG/CR-5512 (25% of total diet as defined in R.G. 1.109) allows one to take the values for specific nuclides directly from NUREG/CR-5512, which are based on 1 pCi/gm concentrations and multiply by the value to be used for soil volume concentrations.

The simplified form of the equation is given by:

H (ing,i) = FD (ing,i) X C (i,p) [Ref. 9]

Where

H (ing,i) = The committed effective dose equivalent from a 1 year intake of radionuclide i by ingestion, in mrem/yr;

FD (ing,i) = The food ingestion effective dose equivalent factor for the most sensitive organ for radionuclide i, in mrem/pCi, assuming 1 pCi/gm and the dietary input listed below: [Ref. 9]

a) 47.5 Kg/yr of vegetable produce,
b) 27.5 L/yr of milk,
c) 19.2 Kg/yr of meat (beef, pork, poultry)
d) 4.8 Kg/yr of eggs.

= 4.99E-05 mrem/pCi for Co-60 for LLI wall. (@ 1 pCi/gm soil activity) [Ref. 8]

C (i,p) = The soil volume activity, for radionuclide i, in pCi/gm
= 1.54E+00 pCi/gm for Co-60 [Ref. 7]

Therefore,

H (ing,i) = 4.99E-05 mrem/pCi per pCi/gm X 1.54E+00 pCi/gm

= 7.68E-05 mrem/yr

The concentration value used above is based on assumptions so conservative as to overwhelm any consideration of re-concentration within the bulk material itself. This primarily refers to the assumption of essentially infinite extent at the maximum possible concentration.

Residential Use Scenario – Total Effective Dose Equivalent

Direct Exposure + Inhalation Exposure + Food Ingestion Exposure

7.85E+00 mrem/yr + 1.48E-04 mrem/yr + 7.68E-05 mrem/yr

TEDE = 7.85E+00 mrem/yr

Reconcentration Factor required to raise projected pathway dose to Draft NRC Criteria Value =

RF = 1.91E+00