Safety Light Corporation
4150A Old Berwick Road
Bloomsburg, Pa. 17815
Phone: 570-784-4344
Fax: 570-784-1402
E-Mail: lharmon@safetylight.com

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December 6, 2000

P-5

United States Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, Pa. 19406
Attention: Marie Miller

030-05980

Re: Decommissioning Plan and Cost Estimate for license no. 37-00030-02
Revisions & Submittal of the Decommissioning Cost Estimate for license no. 37-00030-08

Dear Ms. Miller,

Enclosed are revised pages for the Decommissioning Cost Estimate and the Decommissioning Plan. Please replace these pages in the submittal that you have and destroy the ones that are replaced. Attachment 1 is in its entirety and should replace the Attachment 1 in the Decommissioning Plan. All the above is for License No. 37-00030-02.

Although you are not involved with license no. 37-00030-08, I have included the Decommissioning Cost Estimate for license no. 37-00030-08 with the above items. This satisfies Condition 20. B of that license. Please route this to whom it may concern.

If you have any further questions, please do not hesitate to contact me.

Very Truly Yours,

Larry Harmon,
Plant Manager

/12886/

NMSS/RGN MATERIALS-002

Please replace pages 3-1, 3-2 and 3-3 of the previously transmitted *Decommissioning Cost Estimate for Safety Light Corporation; Bloomsburg, Pennsylvania; NRC Material License No. 37-00030-02*; Revision 0, dated October, 2000 with the attached sheets.

3.0 DECOMMISSIONING CRITERIA

GTS Duratek engineers visited the Safety Light facility in Bloomsburg, Pennsylvania in June of 2000 to gather physical and radiological data. Facility sketches, building sketches, and radiological data for affected areas were obtained. On site staff members were interviewed to determine the radiological history of affected areas and the site in general.

3.1 Radionuclides of Interest

The principle radionuclides of interest are cesium-137, radium-226, strontium-90, and americium-241.

3.2 Radiological Criteria for License Termination

NRC regulations (10 CFR 20.1402) contain two separate and independent requirements for license termination:

- a 25 mrem per year dose limit must be met, and
- levels of residual radioactivity must be ALARA.

There are at least three (3) methods to demonstrate compliance with the license termination ALARA requirement:

- the quantitative method in DG-4006, *Demonstrating Compliance with the Radiological Criteria for License Termination*, including the D&D code; (NRC 1998b)
- by reference to other appropriate analyses (e.g., the Generic Environmental Impact Statement, NUREG-1496); and
- qualitative judgments (e.g., good practice, engineering judgment, unreasonable expense).

This report applies the quantitative method in DG-4006.

The proposed Derived Concentration Guideline Levels (DCGLs) for surface contamination at the Safety Light facility were calculated using RESRAD-BUILD and the ALARA calculation methodology from DG-4006 (NRC 1998b) (Refer to Attachment 1, Safety Light Dose Assessment, of the current decommissioning plan.) Buildings with surface contamination below these levels will be deemed acceptable for release for unrestricted use provided that (NRC 2000):

- Residual radioactivity has been reduced to levels that are "as low as is reasonably achievable" (ALARA),
- The residual radioactivity is contained in the top layer of the building surface (i.e., there is no volumetric contamination), and
- The fraction of removable surface contamination does not exceed 0.1.

The proposed DCGLs for surface soil (top 15 centimeters) contamination were calculated using RESRAD. (Refer to Attachment 1, Safety Light Dose Assessment, of the current decommissioning plan). These levels will be deemed acceptable for release for unrestricted use provided that (NRC 2000):

- Residual radioactivity has been reduced to levels that are ALARA,
- The residual radioactivity is contained in the top layer of the surface soil (i.e., a thickness of approximately 15 cm),
- The unsaturated zone and the groundwater are initially free of radiological contamination, and
- The vertical saturated hydraulic conductivity at the specific site is greater than the infiltration rate.

Additional subsurface soil analyses were required for the Safety Light site because there is activity below the surface soil layer. Attachment 1, Safety Light Dose Assessment, of the current decommissioning plan describes the RESRAD runs used to assign DCGLs for areas of soil with subsurface contamination. The numerical release criterion proposed for demonstrating that the dose criterion has been met for soils will be that the sum-of-fractions (quotients of concentrations and DCGLs) of contributing radionuclides shall be less than unity. If a survey unit fails to meet this numerical release criterion, the need for additional sampling or remediation will be evaluated. Table 3-1 lists the proposed DCGLs for surfaces and soil.

Table 3-1: DCGLs for Surfaces and Soil

Radionuclide	Surface Contamination DCGL (dpm/100cm^2)	Soil with Surface Contamination (to 15 cm) DCGL (pCi/g)	Soil with Subsurface Contamination (to 2 m deep) DCGL (pCi/g)
H-3	1.1 E+08	11,420	1,024
Sr-90	43,160	30.1	5.0
Cs-137	40,500	14.1	11.0
Ra-226 + C	2,170	4.1	1.5
Am-241	112	10.0	1.0

+C indicates the value for radium-226 with its decay progeny in equilibrium. This value is the concentration of the parent radionuclide, but accounts for contributions from the complete chain of progeny in equilibrium with the parent radionuclide.

3.3 Characterization Data

The 1995 site characterization (Monserco 1996) included direct measurements of accessible structures and equipment and soil and water sampling. The principle radionuclides of interest are cesium-137, radium-226, and americium-241. Cobalt-60, strontium-90, polonium-210, and tritium were also detected. The outdoor area surveys were performed after establishing a grid pattern for the site. This grid pattern is shown in Figure 3-1. Figures 3-2 and 3-3 show the relative cesium-137 and radium-226 activity found in surface soils by survey grid.

Please replace pages 2-1, 2-2, 4-5, 4-6, 4-7, and all of Attachment 1, Safety Light Dose Assessment, of the previously transmitted *Decommissioning Plan for Safety Light Corporation; Bloomsburg, Pennsylvania; NRC License No. 37-00030-02*; Revision 0, dated October, 2000 with the attached sheets.

2 DESCRIPTION OF PLANNED DECOMMISSIONING ACTIVITIES

2.1 *Decommissioning Criteria*

The overall objective of the Safety Light decommissioning is to remediate retired facilities and soil areas to a condition that corresponds to a calculated dose to the public of less than 25 mrem/year from applicable pathways. The facilities and land may then be released for unrestricted use. This dose limit appears in 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (NRC 2000a).

The Derived Concentration Guideline Level (DCGL) is defined in MARSSIM (USEPA et. al. 1997) as the radionuclide-specific concentration within a survey unit corresponding to the release criterion. The DCGL is dependent upon several factors including the radionuclides of interest, applicable dose pathways, area occupancy and the future use of the facility. DCGLs assume a uniform level of residual radioactivity across the survey unit.

For site-specific analysis, licensees may use models other than the DandD code to demonstrate compliance with the 25 mrem criteria, provided they can demonstrate that the model and parameters used in that model are appropriate for the site (NRC 2000b).

The proposed DCGLs for surface contamination at the Safety Light facility were calculated using RESRAD-BUILD and the ALARA calculation methodology from DG-4006. (Refer to Attachment 1, Safety Light Dose Assessment, for these calculations and the associated ALARA analysis.) Buildings with surface contamination below these levels will be deemed acceptable for release for unrestricted use provided that (NRC 2000b)

- residual radioactivity has been reduced to levels that are “as low as is reasonably achievable” (ALARA),
- the residual radioactivity is contained in the top layer of the building surface (i.e., there is no volumetric contamination), and
- the fraction of removable surface contamination does not exceed 0.1.

The proposed DCGLs for surface soil (top 15 centimeters) contamination were calculated using RESRAD. (Refer to Attachment 1, Safety Light Dose Assessment, for these calculations and the associated ALARA analysis). These levels will be deemed acceptable for release for unrestricted use provided that (NRC 2000b)

- residual radioactivity has been reduced to levels that are ALARA,

- the residual radioactivity is contained in the top layer of the surface soil (i.e., a thickness of approximately 15 cm),
- the unsaturated zone and the groundwater are initially free of radiological contamination, and
- the vertical saturated hydraulic conductivity at the specific site is greater than the infiltration rate.

Additional subsurface soil analyses were required for the Safety Light site because there is activity below the surface soil layer. Attachment 1, Safety Light Dose Assessment, describes the RESRAD runs used to assign DCGLs for areas of soil with subsurface contamination. The numerical release criterion proposed for demonstrating that the dose criterion has been met for soils will be that the sum-of-fractions (quotients of concentrations and DCGLs) of contributing radionuclides shall be less than unity. If a survey unit fails to meet this numerical release criterion, the need for additional sampling or remediation will be evaluated.

The following table lists the proposed DCGLs for surfaces and soil.

Table 2-1, DCGLs for Surfaces and Soil

Radionuclide	Surface Contamination DCGL ($dpm/100cm^2$)	Soil with Surface Contamination (to 15 cm) DCGL (pCi/g)	Soil with Subsurface Contamination (to 2 m deep) DCGL (pCi/g)
H-3	1.1 E+08	11,420	1,024
Sr-90	43,160	30.1	5.0
Cs-137	40,500	14.1	11.0
Ra-226 + C	2,170	4.1	1.5
Am-241	112	10.0	1.0

+C indicates the value for radium-226 with its decay progeny in equilibrium. This value is the concentration of the parent radionuclide, but accounts for contributions from the complete chain of progeny in equilibrium with the parent radionuclide.

Table 4-1, Survey Unit Classification	
Survey Unit Description	**MARSSIM Classification**
Room 99	Class 2
Room 100	Class 1
Room 101	Class 1
Room 102	Class 2
Room 103	Class 1
Room 104	Class 1
Room 105	Class 1
Room 106	Class 1
Room 107	Class 1
Room 108	Class 1
Room 110	Class 1
Room 111	Class 2
Room 112	Class 1
Room 113A	Class 1
Room 113B	Class 1
Room 113C	Class 1
Room 114	Class 1
Room 115	Class 1
Room 116	Class 2
Room 117	Class 2
Room 119	Class 2
Room 120	Class 1
Room 121	Class 1
Room 122	Class 2
Room 123	Class 2
Room 124	Class 2
Room 125	Class 1
Room 126	Class 2
Room 127	Class 1
Room 129	Class 2
Room 130	Class 2
Room 131	Class 2
Room 132	Class 2
Room 135	Class 1
Room 136	Class 2
Room 137	Class 2
Room 139	Class 1
Room 201	Class 1
Room 202	Class 1
Room 203	Class 2
Room 204	Class 1

Table 4-1, Survey Unit Classification

Survey Unit Description	MARSSIM Classification
Room 205	Class 1
Room 206	Class 2
Room 207	Class 3
Room 208	Class 2
Room 209	Class 1
Room 210	Class 2
Room 211	Class 1
Room 212	Class 2
Room 213	Class 2
Room 214	Class 1
Room 215	Class 1
Room 216	Class 1
Room 217	Class 1
Room 218	Class 1
Room 301	Class 1
Etching Building	
Room 1	Class 1
Room 2	Class 1
Room 3	Class 1
Room 4	Class 1
Room 5	Class 1
Room 6	Class 1
Room 7	Class 1
Room 8	Class 1
Room 9	Class 1
Room 10	Class 1
Room 11	Class 1
Room 12	Class 1
Room 13	Class 1
Room 14	Class 2
Room 15	Class 1
Room 16 (17A)	Class 1
Room 17	Class 1
Room 18	Class 2
Room 19	Class 2
Room 20	Class 1
Room 21	Class 1
Room 22	Class 1
Room 23	Class 1
Room 24	Class 1

Table 4-1, Survey Unit Classification	
Survey Unit Description	**MARSSIM Classification**
Room 25	Class 1
Room 26	Class 1
Room 27	Class 1
Room 28	Class 1
Room 29	Class 1
Room 30	Class 1
Room 31	Class 1
Room 32	Class 1
Room 33	Class 1
Room 34	Class 2
Room 35	Class 2
Room 36	Class 1
Room 38	Class 1
Room 40	Class 1
Room 41	Class 1
Room 45	Class 1
Room 48	Class 1
Room 49	Class 1
Room 50	Class 1
Room 51	Class 2
Room 55	Class 1
Room 56	Class 1
Room 58	Class 1
Room 59	Class 1
Room 60	Class 2
Room 61	Class 1
Room 62	Class 1
Room 63	Class 2
Room 65	Class 1
Room 66	Class 2
Room 67	Class 1
Room 69	Class 1
Room 70	Class 1
Room 71	Class 1
Room 72	Class 1
Room 73	Class 1
Room 74	Class 1
Room 75	Class 1
Room 76A	Class 1
Room 76B	Class 1
Room 78	Class 2

ATTACHMENT 1
SAFETY LIGHT DOSE ASSESSMENT

SURFACE CONTAMINATION

The proposed DCGLs for surface contamination at the Safety Light facility were calculated using RESRAD-BUILD 3.0 and the ALARA calculation methodology from DG-4006.

Except for the following, the default RESRAD-BUILD parameters were used.

1. The fraction of time spent inside the modeled room was 0.2283, based on a worker scenario of working 50 weeks a year 5 days a week for 8 hours per day.

2. The room dimensions were changed to match main building room 88: 10.6 meters by 16.7 meters by 3.6 meters tall.

3. Six surface sources were used that represent the floor, ceiling and four walls. The activity used for each radionuclide of interest was 1 pCi per square meter.

4. The radionuclide lifetime days were increased from 365 days to 4,015 days (11 years). This lifetime was used based on Argonne National Laboratory recommended parameters for *Derivation of Generic Surface Contamination Guidelines for Ra-226, Th-230, Th-232 and Natural Uranium for Building Occupancy and Building Renovation Scenarios* (information provided in an Argonne National Laboratory RESRAD-BUILD workshop June 21, 2000). In addition, the Safety Light facility history demonstrates that the radium material surface contamination has already had a life in excess of 11 years.

5. The inhalation rate was increased from 18 to 28.8 cubic meters per day based on Argonne National Laboratory recommendations (same as item 4 above).

6. The air release fraction was increased from the default value of 0.1 to 0.5 to be more conservative.

RESRAD-BUILD was used to calculate dose rates from 1 pCi/m^2 of tritium, strontium-90, cesium-137, radium-226 and americium-241. These values were then used to calculate the activity (in pCi/m^2) required to generate a dose rate of 25 mrem per year. This activity was then converted to $dpm/100cm^2$ to arrive at the building surface activity required to generate a dose rate of 25 mrem per year. These calculations and results are presented below in Tables 1, 2 and 3.

Table 1, Building Surface Calculated Dose from 1pCi/m²

H-3 mrem/y	Sr-90 mrem/y	Cs-137 mrem/y	Ra-226 mrem/y	Am-241 mrem/y
5.14E-09	1.06E-05	1.11E-05	1.55E-04	3.07E-03

Dose Limit: 25 mrem/yr.

Table 2, Building Surface Activity (pCi/m²) equivalent to 25 mrem/year

H-3 pCi/m²	Sr-90 pCi/m²	Cs-137 pCi/m²	Ra-226 pCi/m²	Am-241 pCi/m²
4.86E+09	2.36E+06	2.25E+06	1.61E+05	8.14E+03

1 picocurie = 2.22 dpm
$1\ m^2 = 10{,}000\ cm^2$

Table 3, Building Surface Activity (dpm/100 cm²) equivalent to 25 mrem/yr.

Radionuclide	Surface Contamination (dpm/100 cm²)
H-3	1.1 E+08
Sr-90	5.2 E+04
Cs-137	5.0 E+04
Ra-226	3.5 E+03
Am-241	1.8 E+02

ALARA CALCULATIONS FOR BUILDING SURFACE DCGL'S

NRC regulations (10 CFR 20.1402) contain two separate and independent requirements for license termination:

- a dose limit must be met, and
- levels of residual radioactivity must be ALARA.

This Safety Light Corporation Decommissioning Plan meets both requirements.

Two different ALARA requirements apply to decommissioning:

- 10 CFR 20.1101(b) requires the licensee to use procedures and engineering controls to maintain doses ALARA during operations (including decommissioning activities), and

- 10 CFR 20.1402 requires that levels of residual radioactivity be ALARA in order to terminate a license.

The latter ALARA requirement is the topic of these calculations.

The method used to demonstrate compliance with the license termination ALARA requirement is the quantitative method in NRC Draft Regulatory Guide DG-4006. (NRC 1998b) The DG-4006 method evaluates the practicality of a cleanup action by quantitatively comparing its costs with the monetary worth of its benefits. A simple equation is used to evaluate the costs versus the benefits of each potential cleanup action.

The DG-4006 method includes the following steps.

- Identify potential cleanup actions that will not be necessary to meet the dose limit.

- For each potential cleanup action, compare the costs vs. the benefits using the equation in DG-4006.

- If a potential cleanup action is cost beneficial, the action must be performed to meet the ALARA requirement.

This method is performed during the remediation planning process before remediation starts. The method uses characterization data to determine if potential cleanup actions not necessary to meet the dose limit are necessary to meet the ALARA requirement.

The Safety Light Corporation site has tritium, strontium-90, cesium-137, radium-226, and americium-241 on building surfaces from licensed operations. SLC proposes to release the site for unrestricted use. Surfaces with activity levels in excess of the DCGLs would be decontaminated to meet these limits.

Table 4: Safety Light Building Surface RESRAD-BUILD Results – Single Radionuclide Minimum Guidelines

	H-3	Sr-90	Cs-137	Ra-226	Am-241
Surface Activity (dpm/100cm^2)	1.1E+08	52,000	50,000	3,500	180

The ALARA goals proposed by the Safety Light Corporation are lower than the dose-based guideline values in Table 4 above for all radionuclides except tritium. The dose-based guidelines for the unrestricted area (25 mrem/yr) were calculated for tritium, strontium-90, cesium-137, radium-226, and americium-241 using RESRAD-BUILD for an industrial occupancy scenario.

For the simplest case, areas that contain only radium for unrestricted release, Equation 18 from DG-4006 was used to calculate the ALARA concentration.

$$\frac{C_{ALARA}}{DCGL_W} = \frac{Cost_T}{\$2000 \times P_D \times 0.025 \times F \times A} \times \frac{r+\lambda}{1-e^{-(r+\lambda)N}}$$

where:

C_{ALARA} = concentration at which the benefit from removal equals the cost of removal

$Cost_T$ = total cost of remediation

P_D = population density based on occupancy scenario

F = fraction of residual radioactivity removed by remediation action

A = area being evaluated in m^2

r = monetary discount rate in units of yr^{-1}

λ = radiological decay constant for the radionuclide in units of yr^{-1}

N = number of years over which the collective dose will be calculated

The first step was to identify the potential cleanup actions to be evaluated. The actions proposed include:

- decontaminate the surfaces exceeding the DCGL values, and dispose of the waste at Envirocare of Utah; and
- leave the activity in place.

The second step was to estimate the cost of each alternative. The "leave in place" option has zero cost. The costs for several proposed decontamination methods are provided in Table 6.

The third step was to evaluate the other parameters in Equation 18.

Table 5, Equation 18 Parameters

Parameter	Value	Basis
DCGLw	3,500 dpm/100cm^2	RESRAD_BUILD dose modeling for Ra-226
P_D	0.09 person/m^2	NUREG-1496, Vol 2, App. B, Table A.1
F	1	Total Removal
\$/person-rem	\$2,000	NUREG/BR-0058
A	100 m^2	Site Information
r	0.07/yr	NUREG/BR-0058
N	70 yr	NUREG-1496, Vol 2, App. B, Table A.1
λ	0.000433	radioactive decay data

The fourth step was to calculate the ALARA concentrations using the above values in equation 18. The ALARA calculations for several decontamination methods and each radionuclide of interest are given in Table 6 below.

Table 6, Building Surface ALARA Calculation Results

Method	1/4" Scabbling of Floor Surfaces	1/8" Scabbling of Wall Surfaces	1/8" Wood Planing Walls & Floors
$Cost_T$	\$4,931	\$11,033	\$3,902
H-3 $C_{ALARA}/DCGL_W$	1.39	3.10	1.10
Sr-90 $C_{ALARA}/DCGL_W$	1.04	2.33	0.83
Cs-137 $C_{ALARA}/DCGL_W$	1.02	2.29	0.81
Ra-226 $C_{ALARA}/DCGL_W$	0.78	1.74	0.62
Am-241 $C_{ALARA}/DCGL_W$	0.79	1.77	0.62
H-3 Surface C_{ALARA}	152,900,000	341,000,000	121,000,000
Sr-90 Surface C_{ALARA}	54,080	121,160	43,160
Cs-137 Surface C_{ALARA}	51,000	114,500	40,500
Ra-226 Surface C_{ALARA}	2,730	6,090	2,170
Am-241 Surface C_{ALARA}	142	319	112

This calculation indicates the $C_{ALARA}/DCGL_W$ ratio is 0.78 for radium-226 contamination on concrete floor surfaces, or the C_{ALARA} value is smaller than the $DCGL_W$ value. For building concrete floor surfaces a radium-226 $DCGL_W$ value of 3,500 dpm/100cm^2 results in a C_{ALARA} value of 2,730 dpm/100cm^2. Therefore, building concrete floor surfaces with concentration in excess of 2,730 dpm/100cm^2 radium-226 will need to be decontaminated further to meet the ALARA requirement because it is more restrictive than the dose limit.

Similarly, these calculations indicate the $C_{ALARA}/DCGL_W$ ratio is 1.74 for radium-226 contamination on concrete wall surfaces, or the C_{ALARA} value is larger than the $DCGL_W$ value. For building concrete wall surfaces, a radium-226 $DCGL_W$ value of 3,500 dpm/100cm^2 results in a C_{ALARA} value of 6,090 dpm/100cm^2. Therefore, building concrete wall surfaces must meet the 3,500 dpm/100cm^2 radium-226 dose limit only.

In addition, these calculations indicate the $C_{ALARA}/DCGL_W$ ratio is 0.62 for radium-226 contamination on building wood surfaces, or the C_{ALARA} value is smaller than the $DCGL_W$ value. For building wood, a radium-226 $DCGL_W$ value of 3,500 dpm/100cm^2 results in a C_{ALARA} value of 2,170 dpm/100cm^2. Therefore, building wood surfaces with concentration in excess of 2,170 dpm/100cm^2 radium-226 will need to be decontaminated further to meet the ALARA requirement because it is more restrictive than the dose limit.

All building areas where elevated activity levels are indicated from characterization surveys will be decontaminated to remove surface material by a method such as HEPA vacuuming prior to evaluating the need for additional remediation by comparison with the ALARA concentration levels.

SURFACE AND SUBSURFACE SOILS

The RESRAD 6.0 computer code was used in assigning DCGLs for soil with surface contamination (to 15 centimeters) and soil with subsurface contamination (to 2 meters) for the Safety Light site. The numerical release criterion proposed for demonstrating that the dose criterion has been met for soils will be that the sum-of-fractions (quotients of concentrations and DCGLs) of contributing radionuclides shall be less than unity. If a survey unit fails to meet this numerical release criterion, the need for additional sampling or remediation will be evaluated.

Except for the following, the default RESRAD parameters for the resident farmer scenario were used.

1. The surface cover layer is not modeled.

2. An average annual precipitation of 1.18 meters was used (46.49 inches). This value was obtained from climatic data for Freeland, Pennsylvania, which is 25 miles east of the Safety Light site.

3. The groundwater at the site averages 3 meters below the surface (refer to Table 7), but the depth to the saturated zone was assumed to be 2 m to be conservative. For the surface soil RESRAD calculation, it was assumed that the surface contaminated soil is 15 centimeters thick. This leaves a 1.85 meter thick unsaturated layer. For the subsurface soil RESRAD calculation, it was assumed that the contaminated soil is 2 meters thick. It is known that some radioactive materials were buried on site at unknown depths and 2 meters deep is appropriate for general disposal.

4. The soil at the site is primarily a gravelly silt loam (Monserco 1996). Values for soil parameters for this site were obtained based upon this soil description from the RESRAD *Data Collection Handbook* (Yu 1993).

5. The soil density, ρ = 1.28, was obtained from Table 2.1 of the *Data Collection Handbook* (Yu 1993).

6. The hydraulic conductivity, K, was obtained from Table 5.2 of the *Data Collection Handbook* (Yu 1993). The saturated hydraulic conductivity was 227 meters/year for *silty loam*. However, the *Data Collection Handbook* indicates that if values in the literature are used in place of actual site data, no more than one significant digit is appropriate. Therefore, a value of 200 meters/year was used for the saturated zone.

7. The *Data Collection Handbook* (Yu 1993) also indicates that in RESRAD, the saturated hydraulic conductivity values related to the contaminated and unsaturated zones of the soil should represent the vertical component of K. Soil with a spatial variability is typical during the geological formation of soils. These soils are called anisotropic and the vertical component of K is typically one or two orders of magnitude lower than the horizontal. Therefore, a value of 20 meters/year was used for the contaminated and unsaturated zones.

8. The Soil-Specific Exponential b Parameter obtained from Table 13.1 of the *Data Collection Handbook* (Yu 1993) was 5.3 (same as RESRAD default value) for *silty loam*.

Table 7, Safety Light Corporation Ground Water

Well	Location	Ground Water Depth (m)
M1	North of Lacquer Storage Bldg.	4.27
M2	SE corner of SLC property, southeast of excavation site #2	2.26
M3	Southwest corner of Safety Light property, beside creek	1.04
M4	East of East Lagoon	2.29
M5	Southeast of East Lagoon	1.52
M6	Southwest of excavation site #1	1.66
M7	Southeast of Well House, Northwest of Buried Silos	4.11
M8	South of Liquid Waste Building	3.35
M9	South of West Silo	3.96
M10	South of East Silo	3.96
M11	South of Lacquer Storage Building	3.35
M12	By Cs-137 log hot spot	1.83
M13	West Dump	4.88
	Average	**2.96**

The RESRAD results were:

Table 8, Soil Activity equivalent to 25 mrem/year

Radionuclide	Soil with Surface Contamination (to 15cm deep) (pCi/g)	Soil with Subsurface Contamination (to 2 m deep) (pCi/g)
H-3	11,420	1,024
Sr-90	30.1	5.0
Cs-137	14.1	11.0
Ra-226 + C	4.1	1.5
Am-241	10.0	1.0

+C indicates the value for radium-226 with its decay progeny in equilibrium. This value is the concentration of the parent radionuclide, but accounts for contributions from the complete chain of progeny in equilibrium with the parent radionuclide.

ALARA CALCULATIONS FOR SOIL DCGL'S

NRC regulations (10 CFR 20.1402) contain two separate and independent requirements for license termination:

- a dose limit must be met, and
- levels of residual radioactivity must be ALARA.

This Safety Light Corporation Decommissioning Plan meets both requirements.

Two different ALARA requirements apply to decommissioning:

- 10 CFR 20.1101(b) requires the licensee to use procedures and engineering controls to maintain doses ALARA during operations (including decommissioning activities), and
- 10 CFR 20.1402 requires that levels of residual radioactivity be ALARA in order to terminate a license.

The latter ALARA requirement is the topic of these calculations.

The method used to demonstrate compliance with the license termination ALARA requirement is the quantitative method in NRC Draft Regulatory Guide DG-4006. (NRC 1998b) The DG-4006 method evaluates the practicality of a cleanup action by quantitatively comparing its costs with the monetary worth of its benefits. A simple equation is used to evaluate the costs versus the benefits of each potential cleanup action.

The DG-4006 method includes the following steps.

- Identify potential cleanup actions that will not be necessary to meet the dose limit.
- For each potential cleanup action, compare the costs vs. the benefits using the equation in DG-4006.
- If a potential cleanup action is cost beneficial, the action must be performed to meet the ALARA requirement.

This method is performed during the remediation planning process before remediation starts. The method uses characterization data to determine if potential cleanup actions not necessary to meet the dose limit are necessary to meet the ALARA requirement.

The Safety Light Corporation site has tritium, strontium-90, cesium-137, radium-226, and americium-241 in the soil from licensed operations. The soil with residual radioactivity includes several different areas and varies from 15 centimeters to about 2 meters thick.

SLC proposes to release the site for unrestricted use. Soil with high concentrations would be removed from the site to a licensed off-site disposal facility.

Table 9, Proposed Safety Light Soil DCGLs (pCi/g)

Radionuclide	H-3	Sr-90	Cs-137	Ra-226	Am-241
Soils with Surface Contamination (to 15 cm depth)	11,420	30.1	14.1	4.1	10.0
Soils with Subsurface Contamination (to 2-m depth)	1,024	5.0	11.0	1.5	1.0

The ALARA goals proposed by the Safety Light Corporation are the same as the dose based guideline values in the table above. The above DCGLs for the unrestricted area (25 mrem/yr) were calculated using RESRAD for the resident farmer scenario using site-specific parameters.

For the simplest case, areas that contain only radium for unrestricted release, Equation 18 from DG-4006 was used to calculate the ALARA concentration.

$$\frac{C_{ALARA}}{DCGL_W} = \frac{Cost_T}{\$2000 \times P_D \times 0.025 \times F \times A} \times \frac{r + \lambda}{1 - e^{-(r+\lambda)N}}$$

The first step was to identify the potential cleanup actions to be evaluated. The actions proposed include

- dispose of soil at Envirocare of Utah, and
- leave the activity in place.

The second step was to estimate the cost of each alternative. The "leave in place" option has zero cost. The direct cost of offsite disposal of surface soils (15 cm depth) over a 1,000 square meter area with more than 4.1 pCi Ra-226 per gram of soil was estimated to be $424,000 per 5,300 cubic feet (302 tons) of soil.

Other costs can include the costs of worker accidents and dose during remediation, traffic fatalities, etc. For Safety Light there was no need to estimate other costs because they would not affect the outcome of the analysis.

The third step was to evaluate the other parameters in Equation 18.

Table 10, Equation 18 Parameters

Parameter	Value	Basis
$DCGL_W$	4.1 pCi/g	RESRAD Dose modeling for Ra-226
P_D	0.0004 person/m^2	NUREG-1496, Vol 2, App. B, Table A.1
F	1	Total Removal
$/person-rem	$2,000	NUREG/BR-0058
A	1,000 m^2	Site Information
r	0.03/yr	NUREG/BR-0058
N	1,000 yr	NUREG-1496, Vol 2, App. B, Table A.1
λ	0.000433	radioactive decay data

The fourth step was to calculate the ALARA concentrations using the above values in equation 18 for radium-226 contamination. This calculation indicates the $C_{ALARA}/DCGL_W$ ratio is 645 or the C_{ALARA} value is over six hundred times larger than the $DCGL_W$ value. For a surface soil radium-226 $DCGL_W$ value of 4.1 pCi/g the C_{ALARA} value is 2,645 pCi/g. Therefore, no surface soil with concentrations in excess of 4.1 pCi/g radium-226 need be shipped for offsite disposal to meet the ALARA requirement because the dose limit is more restrictive. In addition, the removal of subsurface soils is slightly more expensive than for surface soils and the $C_{ALARA}/DCGL_W$ ratio will be even larger. Therefore, no subsurface soils with concentrations in excess of 1.5 pCi radium-226 per gram need be shipped for offsite disposal to meet the ALARA requirement because the dose limit is more restrictive.

Similar calculations were performed for the other radionuclides of interest at the Safety Light Corporation site. The only Equation 18 values that change for each radionuclide are the $DCGL_W$ value and the λ value. Results from these calculations are presented in the table below.

Table 11, Soil ALARA Calculation Results

Radionuclide	λ	C_{ALARA}/ $DCGL_W$	Surface $DCGL_W$	Surface C_{ALARA}	Subsurface $DCGL_W$	Subsurface C_{ALARA}
H-3	0.0565	1,834	11,420	20,944,280	1,024	1,878,016
Sr-90	0.025	1,166	30.1	35,097	5.0	5,830
Cs-137	0.023	1,126	14.1	15,877	11.0	12,386
Ra-226	0.00043	645	4.1	2,645	1.5	968
Am-241	0.0015	668	10.0	6,680	1.0	668

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