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Contact: S. McGuire (301)415-6204

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DEMONSTRATING COMPLIANCE WITH THE RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review and does not represent an official NRC staff position.

Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by **August 31, 1999.**

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A. INTRODUCTION

In order to terminate a license and release a site, a licensee must demonstrate that the site is suitable for release in accordance with the criteria for decommissioning in Subpart E, "Radiological Criteria for License Termination," of 10 CFR Part 20, "Standards of Protection Against Radiation." These requirements were published as a final regulation on July 21, 1997 (62 FR 39058).

Under Subpart E, 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use," allows termination of a license and release of a site for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of a critical group that does not exceed 25 millirems (0.25 millisievert) per year and the residual radioactivity has been reduced to levels that are as low as is reasonably achievable (ALARA). According to 10 CFR 20.1403, "Criteria for License Termination Under Restricted Conditions," a site will be acceptable for license termination under restricted conditions if specified conditions are met. Under 10 CFR 20.1404, "Alternate Criteria for License Termination," in unusual situations, the NRC may release sites exceeding the 25-millirem (0.25-millisievert) criterion if certain specified criteria are met.

A working draft of this guide, based on the proposed rule, was published in August 1994 as NUREG-1500, "Working Draft Regulatory Guide on Release Criteria for Decommissioning: NRC Staff's Draft for Comment" (Ref. 1). This draft guide supersedes that document.

This draft guide is being published for use and comment. The NRC plans to issue a final regulatory guide after gaining experience with this guidance and considering comments from the public. Comments from the public may be posted electronically on the NRC's Technical Conference Forum Website under the topic "Final License Termination Rule" at http://techconf.llnl.gov/cgi-bin/topics. Other comments that have been submitted can be reviewed at that site. Written comments may also be submitted to the Rules and Directives Branch, Division of Administrative Services, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

Regulatory guides are issued to describe to the public methods acceptable to the NRC staff for implementing specific parts of the NRC's regulations, to explain techniques used by the staff in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are issued in draft form for public comment to involve the public in developing the regulatory positions.

The information collections contained in this regulatory guide are contained in the requirements of 10 CFR Part 20 which were approved by the Office of Management and Budget, approval number 3150-0014. The NRC may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number.

B. DISCUSSION

This guide covers the release of buildings and soil from NRC's regulatory jurisdiction. It does not cover the release of equipment because release of equipment is not covered by the license termination regulations in 10 CFR 20.1401 to 20.1405. Equipment includes anything not attached to or not an integral part of the building or structure. Examples of parts of buildings or structures that are covered by the regulations include floors, walls, ceilings, doors, windows, sinks, hoods, lighting fixtures, built-in laboratory benches, and built-in furniture. Examples of items that are not part of a building or structure include furniture and appliances that are not built into or attached to the structure, stocks of chemicals, reagents, metals, and other supplies, motor vehicles, and any other items that would not normally be conveyed with a building when it is sold.

This guide contains regulatory positions on dose modeling, final status surveys, ALARA, and restricted use (Regulatory Positions 1, 2, 3, and 4, respectively). Two of the regulatory positions reference NUREG-series reports that provide additional information for demonstrating compliance. While the positions are listed separately, their use in planning for license termination, as well as use of the referenced NUREGs, is interrelated.

1. **Dose Modeling** -- This regulatory position is being developed to provide methods acceptable to the NRC staff for demonstrating compliance with the dose criteria in Subpart E of 10 CFR Part 20. In particular, it addresses dose modeling methods to relate concentrations of residual radioactivity to dose to the average member of the critical group in order to demonstrate that the dose criteria of 10 CFR 20.1402 and 20.1403 have been met. This regulatory position references NUREG-1549, "Using Decision Methods for Dose Assessment To Comply With Radiological Criteria for License Termination" (Ref. 2), which provides an acceptable methodology for calculating dose.

2. **Methods for Conducting a Final Status Survey** -- This regulatory position is being developed to provide guidance on methods acceptable to the NRC staff for conducting a final radiation status survey for buildings and soil prior to terminating the license. This position references NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (Ref. 3); NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey" (Ref. 4); and NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments For Various Contaminants and Field Conditions," as containing acceptable methods for final status surveys.

3. **Analyses** -- This regulatory position is being developed to provide guidance on methods acceptable to the NRC staff to demonstrate that residual radioactivity has been reduced to levels that are ALARA. In addition, it provides staff positions on acceptable methods to demonstrate that further reductions in residual radioactivity are not technically achievable, could cause net public or environmental harm, or are prohibitively expensive.

4. **License Termination Under Restricted Conditions** -- This regulatory position is being developed to provide guidance on methods acceptable to the NRC staff for terminating a license under restricted conditions, including establishing adequate institutional controls, demonstrating adequate financial assurance for release under restricted conditions, and seeking public input on the proposed restrictions.

As noted above, these positions are interrelated in how they would be used during the license termination process. Some examples follow.

- A licensee planning for license termination could use the dose modeling positions in Regulatory Position 1 to assess whether estimated doses at the site will meet the unrestricted use dose criterion of 25 mrem/yr. As explained in NUREG-1549 (Ref. 2), a licensee could make this assessment either by using a generic screening model or by using site-specific analyses. The decision process described in NUREG-1549 can also assist a licensee in determining whether additional remediation is necessary or whether the licensee may have to consider releasing the site under restricted conditions (see the last example below).

- A licensee can refer to the positions on ALARA in Regulatory Position 3 during its planning process to assess whether the levels present at the site are ALARA.

- Regulatory Position 1 on dose modeling can be useful to licensees in estimating the concentration of the residual radioactivity distinguishable from background that would result in a total effective dose equivalent of 25 mrem/yr to an average member of the critical group. This value is referred to throughout the guide as the "derived concentration guideline," the DCGL.

- The estimated DCGL can be used in planning the final status survey described in Regulatory Position 2 to determine whether there is sufficient confidence to conclude that the residual radioactivity in each of the survey units at the site is less than the dose criteria in Subpart E to 10 CFR Part 20.

- In certain cases, licensees may decide to release the site for restricted use. Regulatory Position 4 provides guidance on releasing the site for restricted use in regard to the type of institutional controls needed, the associated financial assurance, and the activities necessary to seek public input on the controls. Before terminating the license, a licensee in this situation can also use the positions on the final status survey in Regulatory Position 2 to determine whether the DCGL corresponding to restricted use had been met.

C. REGULATORY POSITION

1. DOSE MODELING

Dose modeling is used to estimate the total effective dose equivalent (TEDE) to an average member of the critical group from residual radioactivity. The critical group means the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.

1.1 Use of Derived Concentration Guidelines

The concentration of residual radioactivity distinguishable from background that, if distributed uniformly throughout a survey unit, would result in a total effective dose equivalent of 25 millirems per year to an average member of the critical group is called the derived concentration guideline (DCGL).

NUREG-1549 (Ref. 2) describes acceptable methods to calculate DCGL values, methods to calculate site-specific DCGL values for buildings and soil, methods to calculate area factors for use with the elevated measurement comparison, and methods for handling special circumstances in buildings and soil.

In general, it is to the advantage of the licensee to obtain NRC approval of its DCGL and area factors prior to remediating the site and conducting the final status survey because the remediation design and the final status survey design will depend on the DCGL and area factors. Thus, if the remediation and the final status survey were conducted using a DCGL that was subsequently not accepted by the NRC, the remediation effort and final status survey might not be acceptable. Therefore, if a licensee submits a decommissioning plan or license termination plan, the licensee should include the proposed DCGL as a part of the plan. If neither of these documents need to be submitted, the licensee may submit a proposed site-specific DCGL and area factors for NRC review and approval prior to remediation.

1.2 Use of Generic Screening

The DandD code has been developed by the NRC and is presently available at the NRC website, http://techconf.llnl.gov/radcri/java.html. This code may be used to perform generic screening. The minimum justification for the use of the default scenarios and parameters consists of a statement by the licensee that no conditions are reasonably expected to exist at the site, outside those incorporated in the default scenarios and modeling assumptions, that would cause a significant increase in the calculated dose. Scenario descriptions acceptable to the NRC staff for use in generic screening are contained in Volume 1 of NUREG/CR-5512 (Ref. 6). NUREG-1549 (Ref. 2) and Volume 1 of NUREG/CR-5512 provide the rationale for applicability of the generic scenarios, critical groups, and pathways at a site, the rationale and assumptions for scenarios and pathways included (and excluded), the conceptual modeling approaches, and the bases for revising parameters and pathways based on site-specific information. Appendix B.1 to NUREG-1549 provides information that the licensee may use in evaluating whether or not the generic models in DandD are appropriate for its site, given the assumptions made in Volume 1 of NUREG/CR-5512 and the nature of the site. If the NUREG-5512 screening scenarios and groups are used and the DandD code is used to conduct the analysis, the licensee would not need to perform additional quality assurance/quality control on the DandD code, as the NRC has already done so for this code.

In generic screening, the licensee need only provide site-specific final status survey results that are compared with the generic DCGL. If compliance can be demonstrated by using NRC's screening models and parameter values, progression to more site-specific analysis is unnecessary.

1.3 Use of Site-Specific Information

In using site-specific information to derive DCGLs, the licensee should justify the site-specific parameter values and alternative models. Attachment 1 to NUREG-1549 (Ref. 2) provides information regarding the valid ranges for site-specific parameter changes that a licensee could propose within DandD without an additional uncertainty analysis. Licensees should justify their pathway models and justify the elimination of pathways from dose assessments.

Licensees who choose to modify generic scenarios, critical groups, or pathways may use the information in Appendix A.2 to NUREG-1549, which describes a method the licensee may use to consider appropriate critical groups for the site and develop site-specific scenarios and pathways. Site-specific scenarios to calculate doses from residual radioactivity in soil should describe the reasonable land uses and human activities for the future, following license termination. It is reasonable to assume that current land uses in the area will be continued for the period of the dose assessment (1000 years). If a site-specific scenario or screening group will be used for structures, a description of the reasonable use of the structure after license termination for the projected lifetime of the structure should be provided. (If the lifetime cannot be estimated, 70 years, as used in the GEIS, may be used).

Information on acceptable methods for developing site-specific models is contained in Appendix B.2 to NUREG-1549 (Ref. 2), including information on development of the model (B.2.1), use of a deterministic or probabilistic approach (B.2.2), and selection of codes (B.2.3). Information on changing parameters is contained in Appendix C to NUREG-1549.

1.4 Use of Computer Models

If DandD is used to estimate the DCGL, the licensee should provide to the NRC a copy of the report generated by DandD to verify the version of DandD that was used in the analysis. Information on site characterization should be provided to show that DandD is applicable for the site conditions.

If other computer models are used to estimate the DCGL, the license should provide sufficient information to the NRC to allow review of the model, scenarios, and parameters.

2. METHODS FOR CONDUCTING A FINAL STATUS SURVEY

In the NRC's regulations, 10 CFR 20.1501(a) requires licensees to make or cause to be made surveys that may be necessary for the licensee to comply with the regulations in Part 20. In order to comply with the radiological criteria for license termination (in Subpart E of 10 CFR Part 20), the licensee should conduct a final status survey.

The final status survey is the radiation survey performed after an area has been fully characterized, remediation has been completed, and the licensee believes that the area is ready to be released. The purpose of the final status survey is to demonstrate that the area meets the radiological criteria for license termination. The final status survey is not conducted for the purpose of locating residual radioactivity; the historical site assessment and the characterization survey perform that function.

This section of the guide endorses the final status survey method described in NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (Ref 3). This guide also (1) provides additional specific guidance on acceptable values for use in the MARSSIM method, (2) describes how to use the MARSSIM method in a way that is consistent with the dose modeling, (3) describes how to use the MARSSIM method to meet NRC's regulations, (4) and describes how to extend or supplement the MARSSIM method to certain complex situations that may be encountered, such as how to address subsurface residual radioactivity.

2.1 Classification of Areas by Residual Radioactivity Levels

The licensee should classify site areas based on levels of residual radioactivity from licensed activities. The area classification method contained in Section 4.4 of the MARSSIM (Ref. 3) is acceptable to the NRC staff. Its essential features are described below.

The licensee should first classify site areas as impacted or nonimpacted. *Impacted areas* are areas that may have residual radioactivity from the licensed activities. *Nonimpacted areas* are areas without residual radioactivity from licensed activities. Impacted areas should be identified by using knowledge of past site operations together with site characterization surveys. In the final status survey, radiation surveys do not need to be conducted in nonimpacted areas. The licensee should classify impacted areas into three classes, based on levels of residual radioactivity.

Class 1 Areas: Class 1 areas are impacted areas that, prior to remediation, are expected to have concentrations of residual radioactivity that exceed the $DCGL_W$. ($DCGL_W$ is defined in the MARSSIM (Ref. 3).)

Class 2 Areas: Class 2 areas are impacted areas that, prior to remediation, are not likely to have concentrations of residual radioactivity that exceed the $DCGL_W$.

Class 3 Areas: Class 3 areas are impacted areas that have a low probability of containing residual radioactivity.

Surveys conducted during operations or during characterization at the start of decommissioning are the bases for classifying areas. If the available information is not sufficient to designate an area as a particular class, the area either should be classified as Class 1 or should be further characterized. Areas that are considered to be on the borderline between classes should receive the more restrictive classification. Classifications may be changed at any time before the final status survey if more information becomes available to indicate that another classification is more appropriate.

For soils, impacted areas in Classes 1 and 2 should also be classified by whether they have substantial amounts of subsurface residual radioactivity as defined below. This classification should be based on the historical site assessment and site characterization.

Determining whether there is a substantial amount of subsurface residual radioactivity (deeper than 15 centimeters) should not require a complex set of characterization measurements. In most cases there will be either substantial amounts of residual radioactivity or only traces such as in occasional small pockets or from leaching from surface layers by rain water. When there are small amounts of residual radioactivity below 15 centimeters, the MARSSIM (Ref. 3) survey methods for surface measurements are acceptable. When there are substantial amounts of residual radioactivity below 15 centimeters, the dose modeling and the survey methods should be modified to account for the subsurface residual radioactivity.

The presence of subsurface residual radioactivity is mainly determined by the historical site assessment, with knowledge of how the residual radioactivity was deposited. Characterization surveys to detect subsurface residual radioactivity in soil are not routinely conducted unless there is reason to expect that subsurface residual radioactivity may be present.

2.2 Selection and Size of Survey Units

The licensee should divide the impacted area into survey units based on the classification described above. A survey unit is a portion of a building or site that is surveyed, evaluated, and released as a single unit. The entire survey unit should be given the same area classification. Section 4.6 of the MARSSIM (Ref. 3) contains a method acceptable to the NRC staff for dividing impacted areas into survey units. The important features of this method are summarized here.

For buildings, it is normally appropriate to designate each separate room as either 1 or 2 survey units (e.g., floors with the lower half of walls and upper half of walls with ceiling) based on the pattern of potential of residual radioactivity. It is generally not appropriate to divide rooms of normal size (100 m^2 floor area or less) into more than two survey units because the dose modeling is based on the room being considered as a single unit. However, very large spaces such as warehouses may be divided into multiple survey units.

For soil, survey units should be areas with similar operational history or similar potential for residual radioactivity to the extent practical. Survey units should be formed from areas with the same classification to the extent practical, but if areas with more than one class are combined in to one survey unit, the entire survey unit should be given the more restrictive classification. Survey units should have relatively compact shapes and should not have highly irregular (gerrymandered) shapes unless the unusual shape is appropriate for the site operational history or the site topography.

Suggested survey unit areas from MARSSIM (Ref. 3) are given in Table 2.1. These areas are suggested in MARSSIM because they give a reasonable sampling density and they are consistent with most commonly used dose modeling codes. However, the size and shape of a particular survey unit may be adjusted to conform to the existing features of the particular site area.

Table 2.1. Suggested Survey Unit Areas (MARSSIM, Roadmap Table 1).

Class	Suggested Survey Unit Area	
	Structures - floor area	Land
1	up to 100 m^2	up to 2000 m^2
2	100 to 1000 m^2	2000 to 10,000 m^2
3	no limit	no limit

2.3 Selection of Background Reference Areas and Background Reference Materials

2.3.1 Need for Background Reference Areas

Background reference areas are not needed when radionuclide-specific measurements will be used to measure concentrations of a radionuclide that is not present in background. Background reference areas are needed for the MARSSIM method if (1) the residual radioactivity contains a radionuclide that occurs in background or (2) the sample measurements to be made are not radionuclide-specific. The survey unit itself may serve as the reference area when a surrogate radionuclide in the survey unit can be used to determine background. For example, it

may be possible to use radium-226 as a surrogate for natural uranium. (More information on the use of surrogate radionuclides is provided in Section 4.3.2 of the MARSSIM (Ref. 3).) Multiple reference areas may be used if reference areas have significantly different background levels because of the variability in background between areas. (See Regulatory Position 2.3.4 of this guide and Section 13.2 of NUREG-1505 (Ref. 4).) A derived reference area may be used when it is necessary to extract background information from the survey unit because a suitable reference area is not readily available. For example, it may be possible to derive a background distribution based on areas of the survey unit where residual radioactivity is not present.

2.3.2 Characteristics of Soil Reference Areas

The objective is to select nonimpacted background reference areas that have the same radiation concentration as the survey unit. An acceptable method for selecting background areas is contained in Section 4.5 of the MARSSIM (Ref. 3); it is briefly described here.

For soils, reference areas should have a soil type as similar to the soil type in the survey unit as possible. If there is a choice of possible reference areas with similar soil types, consideration should be given to selecting reference areas that are most similar in terms of other physical, chemical, geological, and biological characteristics. Each reference area should have an area at least as large as the survey unit, if practical, in order to include the full potential spatial variability in background concentrations. Reference areas may be offsite or onsite, as long as they are nonimpacted.

2.3.3 Different Materials in a Survey Unit

Survey units may contain a variety of materials with markedly different backgrounds. An example might be a room with drywall walls, concrete floor, glass windows, metal doors, wood trim, and plastic fixtures. It is not appropriate to make each material a separate survey unit because the dose modeling is based on the dose from the room as a whole and because a large number of survey units in a room would require an inappropriate number of samples.

When there are different materials with substantially different backgrounds in a survey unit, the licensee may use a reference area that is a nonimpacted room with roughly the same mix of materials as the survey unit.

If a survey unit contains several different materials, but one material is predominant or if there is not too great a variation in background among materials, a background from a reference area containing only a single material may still be appropriate. For example, a room may be mostly concrete but with some metal beams, and the residual radioactivity may be mostly on the concrete. In this situation where the concrete predominates, it would be acceptable to use a reference area that contained only concrete. However, the licensee should demonstrate that the selected reference area will not result in underestimating the residual radioactivity on other materials.

The licensee may also use measured backgrounds for the different materials or for groups of similar materials. When the licensee decides to use different measured backgrounds for different materials or for a group of materials with similar backgrounds, it is acceptable to perform a one-sample test on the difference between the paired measurements from the survey unit and from the appropriate reference material. An acceptable method to do this is described in detail in Chapter 12 of NUREG-1505 (Ref. 4).

For materials present onsite, either in buildings or as nonsoil materials present in outdoor survey units (e.g., concrete, brick, drywall, fly ash, petroleum product wastes), the licensee should attempt to find nonimpacted materials that are as similar as possible to the materials on the site. Sometimes such materials will not be available. In those situations, the licensee should make a good faith effort to find the most similar materials readily available or use appropriate published estimates.

2.3.4 Differences in Backgrounds Between Areas

When using a single reference area, any difference in the mean radionuclide concentration between the survey unit and the reference area would be interpreted as caused by residual radioactivity from site operations. This interpretation may not be appropriate when the variability in mean background concentrations among different reference areas is a substantial fraction of the $DCGL_W$. When there may be a significant difference in backgrounds between different areas, a Kruskal-Wallis test, as described in Chapter 13 of NUREG-1505 (Ref. 4), can be conducted to determine whether there are, in fact, significant differences in mean background concentrations among potential reference areas.

While NUREG-1505 does not recommend specific values for the Kruskal-Wallis test, the NRC staff recommends at least 15 samples in each of at least 4 reference areas and a Type I error rate of $\alpha_{KW} = 0.2$ to provide an adequate number of measurements for the determination of whether there is a significant difference in the background concentrations. However, different values may be appropriate on a site-specific basis.

If significant differences in backgrounds among reference areas are found, the NRC staff recommends that a value of three times the standard deviation of the mean between the reference areas should be added to the mean background for all reference areas to define a background concentration. A value of three times the standard deviation of the mean is chosen to minimize the likelihood that a survey unit that contains only background would fail the statistical test for release. A two-sample test (see Regulatory Position 2.4) should then be used to test whether the survey unit meets the radiological criteria for license termination. This method is described in detail in Chapter 13 of NUREG-1505.

2.4 Methods To Evaluate Survey Results

All survey units should be evaluated to determine whether the average concentration in the survey unit as a whole is below the $DCGL_W$. If the radionuclide is not present in background and the measurement technique is radionuclide-specific so that comparison with a reference area is not necessary, a one-sample test, the Sign test, should be used. This test is described in Section 8.3 of the MARSSIM (Ref. 3).

When the residual radioactivity contains a radionuclide present in the environment or when the measurements are not radionuclide-specific, the survey unit should be compared to a reference area. When the survey unit will be compared to a reference area, a two-sample test, the Wilcoxon Rank Sum (WRS) test, should be used. This test is described in Section 8.4 of the MARSSIM.

An exception to using a two-sample test when a radionuclide is present in background is when the licensee plans to assume that all the radionuclide activity in the survey unit is caused by licensed operations and none is from background. This could be the case for cesium-137, for

example, because the levels in the environment are often so much less than the $DCGL_W$ that background concentrations may be ignored.

Class 1 survey units that pass the sign test or WRS test but have small areas with concentrations exceeding the $DCGL_W$ should also be tested to demonstrate that those small areas meet the dose criteria for license termination. This test is called the elevated measurement comparison. It is described in Section 8.5.1 of the MARSSIM and summarized here.

To perform the elevated measurement comparison, the size of the area in the survey unit with a concentration greater than the $DCGL_W$ is determined, then the area factor for an area of that size is determined. (The area factor is the multiple of the $DCGL_W$ that is permitted in a limited area of a survey unit. See Regulatory Position 2.7.5.) The average concentration in the area is also determined. The elevated measurement comparison is acceptable if the following condition is met (MARSSIM Equation 8-2):

$$\frac{\delta}{DCGL_W} + \frac{\textit{average concentration in the elevated area} - \delta}{\textit{area factor for elevated area} \times DCGL_W} < 1 \qquad (1)$$

where δ = the average residual radioactivity concentration for all sample points in the survey unit that are outside the elevated area

If there is more than one elevated area, a separate term should be included for each one.

As an alternative to the unity rule expressed in Equation 1, the dose from the actual distribution of residual radioactivity can be calculated if there is an appropriate exposure pathway model available.

2.5 Instrument Selection and Calibration

To demonstrate that the radiological criteria for license termination have been met, the measurement instruments should have an adequate sensitivity, be calibrated properly, and be checked periodically for proper response.

2.5.1 Calculation of Minimum Detectable Concentrations

The licensee should determine the minimum detectable concentration (MDC) for the instruments and techniques that will be used. The MDC is the concentration that a specific instrument and technique can be expected to detect 95% of the time under actual conditions of use.

For scanning building surfaces for beta and gamma emitters, the MDC_{scan} should be determined from the following equation (obtained by combining MARSSIM equations 6-8, 6-9, and 6-10 and using a value recommended in this guide for the index of sensitivity d' of 1.38, which is for 95% detection of a concentration equal to MDC_{scan} with a 60% false-positive rate).

$$MDC_{scan}\ (\textit{building surfaces}) = \frac{270{,}000 \times 1.38\sqrt{B}}{\sqrt{p}\ \epsilon_i\ \epsilon_s\ A\ t} \qquad (2)$$

where: MDC_{scan} = minimum detectable concentration for scanning building surfaces in pCi/m^2

270,000 = conversion factor to convert to pCi/m^2

1.38 = index of sensitivity d'

B = number of background counts in time interval t

p = surveyor efficiency

ϵ_i = instrument efficiency for the emitted radiation

ϵ_s = source efficiency in emissions/disintegration

A = probe's sensitive area in cm^2

t = time interval of the observation while the probe passes over the source in seconds

Based on the measurements described in Reference 7, a surveyor efficiency p of 0.5 represents a mean value for normal field conditions and its use is generally acceptable. If the licensee wants to determine a value appropriate for particular measurement techniques, the information in Reference 7 describes how the value can be determined.

For scanning soil with a sodium iodide gamma detector, the MDC_{scan} values given in Table 6.7 of MARSSIM provide an acceptable estimate of MDC_{scan}.

For static measurements of surface concentrations, the MDC_{static} may be calculated using the following equation (from NUREG-1507, Equation 3-10 (Ref. 5):

$$MDC_{static} = \frac{3 + 4.65\sqrt{B}}{K\,t} \qquad (3)$$

where: MDC_{static} = minimum detectable concentration in pCi/m^2 or pCi/g

B = background counts during measurement time interval t

t = counting time in seconds

K = a calibration constant (best estimate) to convert counts/second to pCi/m^2 or pCi/g and is discussed further in NUREG-1507.

An example using this equation is shown in Section 6.7.1 of the MARSSIM (Ref. 3).

The instruments used for sample measurements at the specific sample locations should have an MDC_{static} less than 50% of the $DCGL_W$ as recommended in Section 4.7.1 of MARSSIM. There is no specific recommendation for the MDC_{scan}, but the MDC_{scan} will determine the number of samples needed as discussed in Regulatory Position 2.7.5.

The licensee should record all numerical values measured, even values below the "minimum detectable concentration" or "critical level," including values that are negative (when the measured value is below the average background). Entries for measurement results should not be "nondetect," "below MDC," or similar entries because the statistical tests can only tolerate a maximum of 40% nondetects.

2.5.2 Instrument Calibration and Response Checks

NRC regulations at 10 CFR 20.1501(b) require that the licensee periodically calibrate radiation measurement instruments used in surveys such as the final status survey.

For in situ gamma measurements, the detector efficiency (count rate per unit fluence rate) should be determined for the gamma energies of interest and the assumed representative depth distribution. The surface and volumetric distributions should be explicitly considered to evaluate potential elevated areas. To calibrate for the representative depth distribution, acceptable methods are to (1) use a test bed with radioactive sources distributed appropriately or (2) use primarily theoretical calculations that are normalized or verified experimentally using a source approximating a point source. The calibration of the source used for the verification source should be traceable to a recognized standards or calibration organization, for example, the National Institute of Standards and Technology.

Some modern instruments are very stable in their response. Thus, as long as instrument response checks are performed periodically to verify that the detector is operating properly, it may be acceptable to calibrate only initially without periodic recalibrations. The initial calibration may be performed by either the instrument supplier or the licensee, but in either case, 10 CFR 20.2103(a) requires that a record describing the calibration be available for inspection by the NRC.

2.5.3 Instrument Response Checks

The response of survey instruments should be checked with a check source to confirm constancy in instrument response each day before use. Licensees should establish criteria for acceptable response. If the response is not acceptable, the instrument should be considered as not responding properly and should not be used until the problem has been resolved. Measurements made after the last acceptable response check should be evaluated and discarded, if appropriate.

The check source should emit the same type of radiation (i.e., alpha, beta, gamma) as the radiation being measured and should give a similar instrument response, but the check source does not have to use the same radionuclide as the radionuclide being measured.

2.6 Scanning Coverage Fractions and Investigation Levels

Scanning is performed to locate small areas of elevated concentrations of residual radioactivity to determine whether they meet the radiological criteria for license termination. The licensee should perform scanning in each survey unit to detect areas of elevated concentrations. The licensee should establish investigation levels for investigating significantly elevated concentrations of residual radioactivity. Acceptable scanning coverage fractions and scanning investigation levels for buildings and land areas are shown in Table 2.2. This table is based on MARSSIM Roadmap Table 2 and Table 5.8 (Ref. 3).

Systematic scans are those conducted according to a preset pattern. Judgmental scans are those conducted to include areas with a greater potential for residual radioactivity. In Class 2 areas, a 10% scanning coverage would be appropriate when there is high confidence that all locations would be below the $DCGL_W$. A coverage of 25% to 50% would be appropriate when there may be locations with concentrations near the $DCGL_W$. A coverage of 100% would be appropriate if there is any concern that the area should have had a Class 1 classification rather than a Class 2 classification. In Class 3 areas, scanning coverage is usually less than 10%. If any location exceeds the scanning investigation level, scanning coverage in the vicinity of that location should be increased to delineate the elevated area.

Table 2.2. Scanning Coverage Fractions and Scanning Investigation Levels

Class	Scanning Coverage Fraction	Scanning Investigation Levels
1	100%	> $DCGL_{EMC}$
2	10 to 100% for soil and for floors and lower walls of buildings. 10 to 50% for upper walls and ceilings of buildings. Systematic and judgmental.	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$.
3	Judgmental.	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$.

Sometimes the sensitivity of static measurements at designated sample points is high enough to detect significantly elevated areas between sample points. If the sensitivity is high enough, only this single set of measurements is necessary. For example, both scanning and sampling for cobalt-60, which emits an easily detectable gamma, can be done with a single set of in situ measurements in some cases.

2.7 Determining the Number of Samples Needed

A minimum number of samples are needed to obtain sufficient statistical confidence that the conclusions drawn from the samples are correct. The method described below from Chapter 5 of the MARSSIM (Ref. 3) is acceptable for determining the number of samples needed.

2.7.1 Determination of the Relative Shift

The number of samples needed will depend on a ratio involving the concentration to be measured relative to the variability in the concentration. The ratio to be used is called the relative shift, Δ/σ_s. The relative shift, Δ/σ_s, is defined in Section 5.5.2.2 of the MARSSIM as:

$$\Delta/\sigma_s = \frac{DCGL_W - LBGR}{\sigma_s} \tag{4}$$

where:

- $DCGL_W$ = derived concentration guideline
- $LBGR$ = concentration at the lower bound of the gray region. The $LBGR$ is the concentration to which the survey unit must be cleaned in order to have an acceptable probability of passing the test (i.e., $1-\beta$).
- σ_s = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system)

The value of σ_s is determined either from existing measurements or by taking limited preliminary measurements of the concentration of the residual radioactivity in the survey unit at about 5 to 20 locations as recommended in Section 5.5.2.2 of the MARSSIM (Ref. 3). If a reference area will be used and the σ_r in the reference area is larger than the σ_s in the survey unit, the larger value should be used.

This guide endorses the MARSSIM recommendation to initially set the *LBGR* equal to 0.5 $DCGL_W$. If the relative shift, Δ/σ_s, exceeds 3, the *LBGR* should be increased until Δ/σ_s is equal to 3. The licensee may refer to MARSSIM, Appendix D, for additional details and information.

2.7.2 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by failing a survey unit that should pass or by passing a survey unit that should fail. When using the statistical tests, larger decision errors may be unavoidable when encountering difficult or adverse measuring conditions. This is particularly true when trying to measure residual radioactivity concentrations close to the variability in the concentration of those materials in natural background.

The α decision error is the probability of passing a survey unit whose actual concentration exceeds the release criterion. A decision error α of 0.05 is acceptable under the more favorable conditions when the relative shift, Δ/σ_s, is large (about 3 or greater). Larger values of α may be considered when the relative shift is small to avoid an unreasonable number of samples. The β decision error is the probability of failing a survey unit whose actual concentration is equal to *LBGR*. Any value of β is acceptable to the NRC.

2.7.3 Number of Samples Needed for the Wilcoxon Rank Sum (WRS) Test

The minimum number of samples, *N*, needed in each survey unit for the WRS test may be determined from the following equation (MARSSIM (Ref. 3) equation 5-1 with *N* redefined as the number of samples in the survey unit):

$$N = \frac{1}{2} \times \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3\,(P_r - 0.5)^2} \qquad (5)$$

where:

N	=	the number of samples in the survey unit
$Z_{1-\alpha}$	=	the percentile represented by the decision error α
$Z_{1-\beta}$	=	the percentile represented by the decision error β
P_r	=	the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the $DCGL_W$ when the survey unit median is equal to the *LBGR* concentration above background
½	=	a factor added to MARSSIM equation 5-1 because *N* always is defined in this guide as the number of samples in the survey unit

Values of P_r, $Z_{1-\alpha}$ and $Z_{1-\beta}$ are tabulated in Tables 5.1 and 5.2 of MARSSIM. *N* is the minimum number of samples necessary in each survey unit. An additional *N* samples will also be needed in the reference area. If *N* is not an integer, the number of samples is determined by rounding up. In addition, the licensee should consider taking some additional samples (MARSSIM recommends 20%) to protect against the possibility of lost or unusable data. Fewer samples increase the probability of an acceptable survey unit failing to demonstrate compliance with the radiological criteria for release.

2.7.4 Number of Samples Needed for Sign Test

The number of samples *N* needed in a survey unit for the Sign test may be determined from the following equation (MARSSIM (Ref. 3) equation 5-2):

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4\,(Sign\ p - 0.5)^2} \tag{6}$$

where:

N	=	number of samples needed in a survey unit
$Z_{1-\alpha}$	=	percentile represented by the decision error α
$Z_{1-\beta}$	=	percentile represented by the decision error β
$Sign\ p$	=	estimated probability that a random measurement for the survey unit will be less than the $DCGL_W$ when the survey unit median concentration is actually at the *LBGR*.

Values of $Z_{1-\alpha}$, $Z_{1-\beta}$, and *Sign p* are tabulated in Tables 5.2 and 5.4 of MARSSIM. In addition, the licensee should consider taking some additional samples (MARSSIM recommends 20%) to protect against the possibility of lost or unusable data. Fewer samples increase the probability of an acceptable survey unit failing to demonstrate compliance with the radiological criteria for release. If a survey unit fails to demonstrate compliance because there were not enough samples taken, a totally new sampling effort may be needed unless resampling was planned for.

2.7.5 Additional Samples for Elevated Measurement Comparison in Class 1 Areas

Additional samples may be needed when the concentration that can be detected by scanning, MDC_{scan}, is larger than the $DCGL_W$. The licensee should determine whether additional samples are needed in Class 1 survey units for the elevated measurement comparison when the concentration that can be detected by scanning, MDC_{scan}, is larger than the $DCGL_W$. The method in section 5.5.2.4 of the MARSSIM (Ref. 3) to determine whether additional samples are needed is acceptable to the NRC staff and is described here.

The area factor is the multiple of the $DCGL_W$ that is permitted in a limited portion of the survey unit. The ratio of the MDC_{scan} to the $DCGL_W$ establishes the area factor (the multiple of the $DCGL_W$) that can be detected by scanning (MARSSIM equation 5-4):

$$area\ factor = \frac{MDC_{scan}}{DCGL_W} \tag{7}$$

Using the methods in NUREG-1549 (Ref. 2), the size of the area corresponding to the area factor, A_{EC}, can be determined. The number of sample points that may be needed to detect this area of elevated measurement concentration, N_{EMC}, in a survey unit is:

$$N_{EMC} = \frac{A}{A_{EC}} \tag{8}$$

where

A	=	the area of the survey unit
A_{EC}	=	the area of concentration greater than $DCGL_W$

If N_{EMC} is larger than N, additional samples may be needed to demonstrate that areas of elevated concentrations meet the radiological criteria for license termination. However, the

number of samples needed is not necessarily N_{EMD}. To determine how many additional samples may be needed, the historical site assessment and site characterization should be considered. Based on what is known about the site, it may be possible to estimate a concentration that is unlikely to be exceeded. If there is a maximum concentration, the size of the area corresponding to this area factor for this concentration may be used for A_{EC} in Equation 8. Similarly, based on knowledge of how the radioactive material was handled or dispersed on the site, it may be possible to estimate the smallest area likely to have elevated concentrations. If this is so, that area can be used in Equation 8. Likewise, knowledge of how the residual radioactivity would be likely to spread or diffuse after deposition could be used to determine an area A_{EC} for Equation 8.

It has been shown in Figure D-7 of Appendix D to MARSSIM and in Section 3.7.2 of NUREG-1505 (Refs. 3 and 4) that a triangular grid is slightly more effective in locating areas of elevated concentrations. Therefore, a triangular grid generally should be used if N_{EMC} is significantly larger than N and if areas similar in size or smaller than the grid spacing are expected to have concentrations at or above the area factor.

2.8 Determining Sample Locations

The licensee should establish a reference coordinate system for the impacted areas. A reference coordinate system is a set of intersecting lines referenced to a fixed site location or benchmark. Reference coordinate systems are established so that the locations of any point in the survey unit can be identified by coordinate numbers. A reference coordinate system does not establish the number of sample points or determine where samples are taken. A single reference coordinate system may be used for a site, or different coordinate systems may be used for each survey unit or for a group of survey units. Section 4.8.5 of the MARSSIM describes an acceptable method to establish a reference coordinate system.

In Class 1 and Class 2 areas, the sampling locations are established in a regular pattern, either square or triangular. The method described below is from in Section 5.5.2.5 of the MARSSIM.

After the number of samples needed in the survey unit has been determined and the licensee has decided whether to use a square or triangular grid, sample spacings are determined from the equations below (adapted from MARSSIM equations 5-5, 5-6, 5-7, and 5-8).

$$L = \sqrt{\frac{A}{0.866\ N}} \quad \textit{for a triangular grid} \tag{9}$$

$$L = \sqrt{\frac{A}{N}} \quad \textit{for a square grid} \tag{10}$$

where A = the survey unit area
N = the number of samples needed (in Class 1 areas, the larger of the number for the statistical test or the elevated measurement. comparison)

The calculated value of L is then often rounded downward to a shorter distance that is easily measured in the field.

A random starting point should be identified for the survey pattern. The coordinate location of the random starting point should be determined by a set of two random numbers, one representing the x axis and the other the y axis. The random numbers can be generated by calculator or computer or can be obtained from a table of random numbers. Each random number should be multiplied by the appropriate survey unit dimension to provide a coordinate relative to the origin of the survey unit reference coordinate system.

Beginning at the random starting point, a row of points should be identified parallel to the x axis at intervals of L. For a square grid, the additional rows should be parallel to the first row at a distance of L from the first row. For a triangular grid, the distance between rows should be 0.866 L, and the sample locations in the adjacent rows should be midway on the x axis between the sample locations in the first row. Sample locations selected in this manner that do not fall within the survey unit area or that cannot be surveyed because of site conditions should be replaced with other sample locations determined using the same random selection process that was used to select the starting point. An example illustrating the triangular grid pattern is shown in MARSSIM in Figure 5.5.

In Class 3 survey units and in reference areas, all samples should be taken at random locations. Each sample location should be determined by a set of two random numbers, one representing the x axis and the other the y axis. Each set of random numbers should be multiplied by the appropriate survey unit dimension to provide coordinates relative to the origin of the survey unit reference coordinate system. Coordinates identified in this manner that do not fall within the survey unit area or that cannot be surveyed because of site conditions should be replaced with other sample locations determined in the same manner. MARSSIM Figure 5.4 illustrates a random sample location pattern.

2.9 Determination of Compliance

The licensee should first review the measurement data to confirm that the survey units were properly classified. The MARSSIM (Ref. 3), in Section 8.2.2, contains methods for this review that are acceptable to the NRC staff. If the final status survey shows that an area was misclassified with a less restrictive classification, the area should receive the correct classification and the final status survey for the area should be repeated. A pattern of misclassifications that are not restrictive enough indicates that the characterization was not adequate. In this case, the site or portions of the site in question should be characterized again, reclassified, and resurveyed for the new classification.

The licensee should then determine whether the measurement results demonstrate that the survey unit meets the radiological criteria for license termination. Tables 2.4 and 2.5 of this guide summarize an acceptable way to interpret the sample measurements. The WRS test is described in Section 8.4 of the MARSSIM. The Sign test is described in Section 8.3 of the MARSSIM. The elevated measurement comparison is described in Section 8.5 of the MARSSIM. The elevated measurement is applied to all sample measurements and all scanning results that exceed the $DCGL_W$.

Some facilities may have residual radioactivity composed of more than one radionuclide. When there are multiple radionuclides rather than a single radionuclide, the dose contribution from each radionuclide needs to be considered.

When there is a fixed ratio among the concentrations of the nuclides, such as for radionuclides that are in secular equilibrium, a $DCGL_W$ for each nuclide can be calculated. Compliance with the radiological criteria for license termination may be demonstrated by comparing the concentration of the single radionuclide that is easiest to measure with its $DCGL_W$.

When there is no fixed ratio among the concentrations of the nuclides, it is necessary to evaluate the concentration of each nuclide. Compliance with the radiological criteria for license termination is then demonstrated by considering the sum of the concentration of each nuclide relative to its $DCGL_W$, calculated as if it were the only nuclide present. An acceptable method for performing the evaluation is described in Chapter 11 of NUREG-1505 (Reference 4).

In some cases in which multiple nuclides are present with no fixed ratio in their concentrations, the dose contribution from one or more of the nuclides in the mixture will dominate the total dose, and the dose from other radionuclides will be insignificant. For example, at a nuclear power plant, many different radionuclides could be present with no fixed ratio in their concentrations, but almost all the dose would come from just one or two of the nuclides. In this situation, the presence of nuclides that likely contribute less than 10% of the total effective dose equivalent may be ignored.

Table 2.4. Interpretation of Sample Measurements When Reference Area Is Used

Measurement results	Conclusion
Difference between maximum survey unit concentration and minimum reference area concentration is less than $DCGL_W$.	Survey unit meets release criterion
Difference between survey unit average concentration and reference area average concentration is greater than $DCGL_W$.	Survey unit fails
Difference between any survey unit concentration and any reference area concentration is greater than $DCGL_W$ and the difference of survey unit average concentration and reference area average concentration is less than $DCGL_W$	Conduct WRS test and elevated measurement comparison

Table 2.5. Interpretation of Sample Measurements When No Reference Area Is Used

Measurement results	Conclusion
All concentrations are less than $DCGL_W$	Survey unit meets release criterion
Average concentration is greater than $DCGL_W$	Survey unit fails
Any concentration is greater than $DCGL_W$ and average concentration less than $DCGL_W$	Conduct Sign test and elevated measurement comparison

If a survey unit fails, the licensee should evaluate the measurement results and determine why the survey unit failed. MARSSIM (Ref. 3) provides acceptable methods for reviewing measurement results in Sections 8.2.2 and 8.5.3 and in Appendix D. If it appears that the failure was caused by the presence of residual radioactivity in excess of that permitted by the radiological release criteria, the survey unit should be re-remediated and resurveyed. However, some failures may not be caused by the presence of residual radioactivity. If it can be determined that this is the case, the survey unit may be released.

2.10 Surveys for Special Situations in Buildings

The survey method described in this section thus far can be applied to simple ideal geometries in a straightforward manner. However, at actual sites there are likely to be some special situations that will need special consideration. For each situation discussed below, it is assumed that the historical site assessment and site characterization have located and given a rough estimate of the concentration of residual radioactivity present.

2.10.1 Residual Radioactivity Beneath the Surface

The historical site assessment and characterization surveys may indicate that residual radioactivity is present beneath the surface. In the dose modeling, the parameters for resuspension and ingestion are normally derived for residual radioactivity on the surface. However, if the residual radioactivity is beneath rather than on the surface, that may be considered in the dose modeling and the survey results may be interpreted in a manner consistent with the dose modeling.

For the final status survey, cracks and crevices are surveyed the same as other building surfaces except that they should be included in places receiving judgmental scans when scanning coverage is less than 100%.

For painted-over residual radioactivity, the historical site assessment and characterization surveys should be used to determine whether residual radioactivity was fixed in place by being painted over. If so, the process for its removal may be considered in developing the parameters for the dose modeling, and the survey results may be interpreted in a manner consistent with the dose modeling.

2.10.2 Sewer Systems, Waste Plumbing Systems, and Floor Drains

The historical site assessment and characterization surveys are used to determine whether there are unusual or unexpected levels of residual radioactivity in sewer systems and floor drains. Residual radioactivity in sewer systems and floor drains generally does not contribute to the dose pathways in the building occupancy scenario or the residential scenario; thus, the dose from residual radioactivity in sewer pipes should be calculated using a site-specific scenario. The final status survey should then be conducted in a manner consistent with the site-specific dose scenario. If the sewer water is sent to an onsite drainage field or cesspool, any residual radioactivity should be evaluated and surveyed as subsurface residual radioactivity. If unusual or unexpected results are found during the characterization survey, the situation will be dealt with on a case-by-case basis.

If sewage is sent to an onsite drainage field, any residual radioactivity is subsurface and the survey methods discussed in Regulatory Position 2.11.1 are appropriate.

2.10.3 Ventilation Ducts

The historical site assessment and characterization surveys should be used to indicate whether residual radioactivity may be present. External duct surfaces of ventilation ducts are surveyed as if they are a part of the building surface. For internal duct surfaces, surveys should be performed consistent with the dose modeling assumptions.

2.10.4 Piping and Embedded Piping

Embedded piping is piping embedded in a durable material, typically concrete, that cannot be easily removed without significant effort and tools. The historical site assessment and characterization surveys should be used to indicate whether residual radioactivity is present in piping. The normal room surveys will adequately account for direct (external gamma) radiation from the pipes when the pipes are in place and undisturbed. The direct (external gamma) dose from the pipes will be in addition to the total effective dose equivalent from the residual radioactivity on surfaces in the room. It may also be necessary to consider renovation of the building that would disturb the piping as described in NUREG/CR-5512 (Ref. 6). If this is done, the survey should be consistent with the dose modeling assumptions.

2.11 Surveys for Special Situations on Land

2.11.1 Subsurface Residual Radioactivity

The MARSSIM (Ref. 3) final status survey method was designed specifically for residual radioactivity in the top 15 centimeters of soil. If significant amounts of residual radioactivity are deeper than 15 centimeters, this should be taken into consideration in performing the final status survey.

The licensee should first determine whether there is a need for surveys of subsurface residual radioactivity. The historical site assessment will usually be sufficient to indicate whether there is likely to be subsurface residual radioactivity. If the historical site assessment indicates that there is no likelihood of substantial subsurface residual radioactivity, subsurface surveys are not necessary.

If the historical site assessment indicates that there is substantial subsurface residual radioactivity and the licensee plans to terminate the license with some subsurface residual radioactivity in place, the final status survey should consider the subsurface residual radioactivity in order to demonstrate compliance with the radiological criteria for license termination. To prepare for the final status survey, the characterization survey determines the depth of the residual radioactivity. The $DCGL_W$ may be based on the assumption that the residual radioactivity may be excavated some day and that mixing of the residual radioactivity will occur during excavation. When the subsurface residual radioactivity is mixed and brought to the surface, most of the dose pathways will depend only on the average concentration. Only the groundwater pathways are affected by the total inventory of residual radioactivity, including that deeper than 15 centimeters. The direct, inhalation, ingestion, and crop pathways are determined by concentration only, not total inventory.

When the appropriate *DCGLs* and mixing volumes based on an acceptable site-specific dose assessment are established, the final site survey is performed by taking core samples to the measured depth of the residual radioactivity. The number of cores to be taken is the number N required for the WRS or Sign test, as appropriate. However, the mixing volume assumed in the scenario may require a larger number of core samples. There is no adjustment to the grid spacing for the elevated measurement comparison because scanning is not

applicable. The core samples should be homogenized over each 1 meter of depth. Then the appropriate test (WRS or Sign) is applied to the set of samples. In addition, each individual core sample is also tested against a site-specific volumetric elevated measurement comparison. Triangular grids are recommended because they are slightly more effective in locating areas of elevated concentrations.

The sampling approach described above may not be necessary if sufficient data to characterize the subsurface residual radioactivity are available from other sources. For example, for some burials conducted under prior NRC regulations, the records on the material buried may be sufficient to demonstrate compliance with the radiological criteria for license termination.

2.11.2 Rubble, Debris, and Rocks

Rocks and debris can include naturally occurring rocks, either in place or in piles, pieces of concrete or rubble from buildings that have been razed, sheet metal disposed of as trash, and similar material. The historical site assessment and characterization surveys should be used to determine whether the volumetric residual radioactivity concentration may be greater than the *DCGL* for soil (based on the approximate size of the pile). If the materials are highly contaminated, they would be disposed of as radioactive waste. If the radioactivity is not substantially elevated, the rubble, debris, and rocks may be evaluated as part of a larger survey unit. The same is true for other nonsoil foreign materials such as asphalt and fly ash. When these materials will be evaluated as part of a larger survey unit and when they are found on a relatively small fraction of the area of a survey unit, the volumetric soil $DCGL_W$ should be used uniformly throughout the survey unit. Areas covered by these materials would not normally be expected to be appropriate for farming or a house site. Because of this, the $DCGL_W$ calculated for soil is expected to be conservative if used for rocks and other debris. In this case, the area should be scanned like the rest of the survey unit, and the sampling locations in the survey unit should be selected without regard to the location of the pile.

2.11.3 Paved Parking Lots, Roads, and Other Paved Areas

The historical site assessment and characterization surveys should be used to determine whether the residual radioactivity is on or near the surface of the paving and whether there are significant concentrations of residual radioactivity beneath the paving. If the residual radioactivity is primarily on top of the paving, the measurements should be taken as if the area were normal soil. Depending on how large the paved area is, the paved area may be included as part of a larger survey unit or may be its own survey unit. If the residual radioactivity is primarily beneath the paving, it should be surveyed as subsurface residual radioactivity, as discussed above.

2.11.4 Ground Water

The need for surveys of ground water should be determined from the historical site assessment. If the historical site assessment indicates that residual radioactivity may have reached potable water, surveys of ground water would be appropriate. The nature of appropriate ground water surveys should be determined on a site-specific basis and is outside the scope of this guide.

2.11.5 Surface Water and Sediments

Surface water can include ponds, creeks, and other bodies of water. The need for surface water samples should be evaluated on a case-by-case basis. Surveys for water should be based on appropriate environmental standards for water sampling.

If the body of water is included in a larger survey unit, sediment samples should be taken at sample locations selected by the normal method without taking the body of water into consideration.

2.12 Records

The recordkeeping requirements for the final status survey are contained in 10 CFR 20.2103(a), which requires that records showing the results of surveys and calibrations required by 10 CFR 20.1501 be maintained for 3 years.

3. ANALYSES

In order to terminate a license, a licensee must demonstrate that the dose criteria of Subpart E have been met and must demonstrate whether it is feasible to further reduce the levels of residual radioactivity to levels below those necessary to meet the dose criteria (i.e., to levels that are "as low as is reasonably achievable (ALARA)). This section of the guide describes methods acceptable to the NRC staff for determining when it is feasible to further reduce the concentrations of residual radioactivity to below the concentrations necessary to meet the dose criteria.

Type I licensees (as defined in Reference 8) do not have to demonstrate whether it is feasible to further reduce the levels of residual radioactivity to levels below those necessary to meet the dose criteria because they have no substantial residual radioactivity. Therefore, they do not need to conduct an explicit analysis to meet the ALARA requirement. In addition, explicit analyses do not have to be done for areas where no residual radioactivity distinguishable from background has been found, as described in Regulatory Position 2. If residual radioactivity cannot be detected, it may be assumed that it has been reduced to levels that are as low as is reasonably achievable.

Areas that have been released under then-existing requirements would not have to be reevaluated under 10 CFR 20.1401(c). According to 10 CFR 20.1401(c), the NRC would require additional cleanup following license termination only if it determines, based on new information, that the criteria of Subpart E were not met and that residual radioactivity remaining at the site could result in significant threat to public health and safety. Because ALARA represents an optimization technique below a dose criteria, it is not considered reasonable to reopen consideration of an area where radioactive materials were handled solely to meet the ALARA requirement.

In general, a method for determining whether levels of residual radioactivity are ALARA would have the following characteristics.

- **The method is simple**. The method should be simple because the effort needed for very sophisticated models cannot be justified. In an ALARA analysis of a remediation action, the primary benefit (i.e., the collective radiation dose that will actually be averted in the future) is uncertain because future land uses, the number of people that will actually occupy a site, and the types of exposure scenarios are all uncertain. These uncertainties mean that the future collective dose cannot be known with precision. Because of the

inherent limitation on the ability to precisely determine the future collective dose at a particular site, it is not useful to perform a complex analysis when a simple analysis can be appropriate.

- **The method is not biased and uses appropriate dose modeling to relate concentrations to dose.** The determination of ALARA should not be biased. This is different from demonstrating compliance with a dose limit. The analyses for dose assessments and surveys for compliance with the dose criteria described in Regulatory Positions 1 and 2 of this guide include a reasonably conservative bias for demonstrating compliance. Unlike a demonstration of compliance, an ALARA analysis is an optimization technique that seeks the proper balance between costs and benefits below the dose limit. To achieve a proper balance, each factor in the ALARA analysis should be determined with as little bias as possible. If the ALARA analysis were intentionally biased, it would likely cause a misallocation of resources and could deprive society of the benefits from other uses of the resources. Thus, the ALARA analysis should provide an unbiased analysis of the remediation action, which can both avert future dose (a benefit to society) and cost money (a potential detriment because it can deprive future generations of the return on the investment of this money). Regulatory Positions 3.1.1 and 3.1.2, respectively, discuss the methods that should be used in estimating benefits and detriments, or costs, including scenarios, models, and parameters for relating concentration to dose at a site. The OMB guidance to Federal agencies that implements the President's Executive Order 12866 (Ref. 10) provides guidance on balancing benefits and detriments for analyzing the potential benefits of Federal regulations (Reference 11).

- **The method is usable as a planning tool for remediation.** Before starting a remediation action, the user should be able to determine what concentration of residual radioactivity would require a remediation action to meet the ALARA requirement. It would be inefficient if the user could not tell whether the area would pass the ALARA test until after the remediation.

- **As much as possible, the method uses the results of surveys conducted for other purposes.** The demonstration that the ALARA requirement has been met should not require surveys beyond those already performed for other purposes, such as the characterization survey and the final status survey. It would be inefficient (and unnecessary) to collect additional sets of measurements to demonstrate that remediation actions were taken wherever appropriate to meet the ALARA requirement if measurements undertaken for other purposes could be used.

3.1 ALARA Analyses

Subpart E of 10 CFR Part 20 contains specific requirements for a demonstration that residual radioactivity has been reduced to a level that is ALARA (10 CFR 20.1402, 20.1403(a), 20.1403(e), and 20.1404(a)(3)). A simplified method for demonstrating compliance with the ALARA requirement is described below. Licensees may use more complex or site-specific analyses if more appropriate for their specific situation. Guidance on more realistic and complex analyses is in Regulatory Position 3.1.7.

The simplified method presented here is to estimate when a remediation action is cost effective. If the desired beneficial effects ("benefits") from the remediation action are greater than the undesirable effects or "costs" of the action, the remediation action being evaluated is

cost effective and should be performed. Conversely, if the benefits are less than the costs, the levels of residual radioactivity are already ALARA without taking the remediation action.

The method should be applied during remediation planning, prior to the start of remediation, but after some or all of the characterization work is done. The method should be used only to determine whether and where particular remediation actions should be taken to meet the ALARA requirement. The method does not establish a concentration that cannot be exceeded. For example, the ALARA method might indicate that the floor of a building should be washed where the concentration exceeds 1 pCi/cm^2. If washing reduces the concentration from 10 pCi/cm^2 to 8 pCi/cm^2 after washing, 8 pCi/cm^2 is ALARA because the remediation action of washing was performed. The ALARA requirement is met by performing the remediation action where appropriate, not by reducing the concentration to below a specified value.

In order to compare the benefits and costs of a remediation action, it is necessary to use a comparable unit of measure. The unit of measure used here is the dollar; all benefits and costs are given a monetary value. Benefits and costs are calculated as described in Regulatory Positions 3.1.1 and 3.1.2 below.

If the licensee has already decided to perform a remediation action, there is no need to analyze whether the action was necessary to meet the ALARA requirement. The analysis described in this section is needed only to justify not taking a remediation action. For example, if a licensee plans to wash room surfaces (either to meet the dose limit or as a good practice procedure), there is no need to analyze whether the remediation action of washing is necessary to meet the ALARA requirement.

3.1.1 Calculation of Benefits

In the simplest form of the analysis, the only benefit estimated from a reduction in the level of residual radioactivity is the monetary value of the collective averted dose to future occupants of the site. For buildings, the collective averted dose from residual radioactivity should be based on the building occupancy scenario. For land, the averted dose should be based on the resident farmer scenario. Additional considerations, such as those related to reducing residual levels so that a site could be released for unrestricted, rather than restricted, use, are discussed in Regulatory Position 3.1.7.

The benefit from collective averted dose, B_{AD}, is calculated by determining the present worth of the future collective averted dose and multiplying it by a factor to convert the dose to monetary value:

$$B_{AD} = \$2000 \times PW(AD_{collective}) \qquad (11)$$

where B_{AD} = benefit from averted dose for a remediation action, in \$
\$2000 = value in dollars of a person-rem averted (from Reference 12)
$PW(AD_{collective})$ = present worth of future collective averted dose

An acceptable value for collective dose is \$2000 per person-rem averted, discounted for dose averted in the future (See Section 4.3.3 of Ref. 12). According to References 11 and 12, for doses averted within the first 100 years, a discount rate of 7% should be used. For doses averted beyond 100 years, a 3% discount rate should be used.

The present worth of the future collective averted dose can be estimated from the equation below for relatively simple situations:

$$PW(AD_{collective}) = P_D \times A \times 0.025 \times F \times \frac{Conc}{DCGL_W} \times \frac{1 - e^{-(r+\lambda)N}}{r+\lambda} \qquad (12)$$

P_D	=	population density for the critical group scenario in people/m^2
A	=	area being evaluated in m^2
0.025	=	annual dose to an average member of the critical group from residual radioactivity at the $DCGL_W$ concentration in rems/yr
F	=	fraction of the residual radioactivity removed by the remediation action. F may be considered to be the removable fraction for the remediation action being evaluated.
$Conc$	=	average concentration of residual radioactivity in the area being evaluated in units of activity per unit area for buildings or activity per unit volume for soils
$DCGL_W$	=	derived concentration guideline equivalent to the average concentration of residual radioactivity that would give a dose of 25 mrem/yr to the average member of the critical group, in the same units as *"Conc"*
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 present worth of the benefit calculated by Equation 2 assumes that the peak dose occurs in the first year. This is almost always true for the building occupancy scenario, but not always true for the residential scenario where the peak dose can occur in later years. When the peak dose occurs in later years, Equation 2 would overestimate the benefit. The licensee may perform a more exact calculation that avoids this overestimation of the benefit of remediation by calculating the dose during each year of the evaluation period and then calculating the present worth of each year's dose.

The $DCGL_W$ used should be the same as the $DCGL_W$ used to show compliance with the 25 mrem/yr dose limit. The population density, P_D, should be based on the dose scenario used to demonstrate compliance with the dose limit. Thus, for buildings, the licensee should estimate P_D for the building occupancy scenario. For soil, the P_D should be based on the residential scenario. The factor at the far right of the equation, which includes the exponential terms, accounts for both the present worth of the monetary value and radiological decay.

If more than one radionuclide is present, the total benefit from collective averted dose, B_{AD}, is the sum of the collective averted dose for each radionuclide. When multiple radionuclides have a fixed concentration (i.e., secular equilibrium), residual radioactivity below the dose criteria is normally demonstrated by measuring one radionuclide and comparing its concentration to a $DCGL_W$ that has been calculated to account for the dose from the other radionuclides. In this case, the adjusted $DCGL_W$ may be used with the concentration of the radionuclide being measured. The other case is when the ratio of the radionuclide concentrations is not fixed and varies from location to location within a survey unit; this benefit is the sum of the collective averted dose from each.

3.1.2 Calculation of Costs

The licensee should evaluate the costs of the remediation actions being evaluated. When doing a fairly simple evaluation, the costs generally include the monetary costs of (1) the remediation action being evaluated, (2) transportation and disposal of the waste generated by the action, (3) workplace accidents that occur because of the remediation action, (4) traffic fatalities resulting from transporting the waste generated by the action, (5) doses received by workers performing the remediation action, and (6) doses to the public from excavation, transport, and disposal of the waste. Other costs that are appropriate for the specific case may also be included.

The total cost, $Cost_T$, which is balanced against the benefits, has several components.

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose} + Cost_{other} \qquad (13)$$

where $Cost_R$ = monetary cost of the remediation action (may include "mobilization" costs)
$Cost_{WD}$ = monetary cost for transport and disposal of the waste generated by the action
$Cost_{ACC}$ = monetary cost of worker accidents during the remediation action
$Cost_{TF}$ = monetary cost of traffic fatalities during transporting of the waste
$Cost_{WDose}$ = monetary cost of dose received by workers performing the remediation action and transporting waste to the disposal facility
$Cost_{PDose}$ = monetary cost of the dose to the public from excavation, transport, and disposal of the waste
$Cost_{other}$ = other costs as appropriate for the particular situation.

All the costs described below do not necessarily have to be calculated. For example, if one or two of the costs can be shown to be in excess of the benefit, the remediation action has been shown to be unnecessary without calculating the other costs.

The cost of waste transport and disposal, $Cost_{WD}$, may be evaluated according to the following equation.

$$Cost_{WD} = V_A \times Cost_V \qquad (14)$$

Where V_A = volume of waste produced, remediated in units of m^3
$Cost_V$ = cost of waste disposal per unit volume, including transportation cost, in units of $\$/m^3$

The cost of nonradiological workplace accidents, $Cost_{ACC}$, may be evaluated using the equation below.

$$Cost_{ACC} = \$3{,}000{,}000 \times F_W \times T_A \qquad (15)$$

where \$3,000,000 = monetary value of a fatality equivalent to \$2000/person-rem (from Ref. 13, pages 11-12)
F_W = workplace fatality rate in fatalities/hour worked

T_A = worker time required for remediation in units of worker-hours

The cost of traffic fatalities incurred during the transportation of waste, $Cost_{TF}$, may be calculated according to the equation below.

(16)

where V_A = volume of waste produced in units of m^3
F_T = fatality rate per kilometer traveled in units of fatalities/km
D_T = distance traveled in km
V_{SHIP} = volume of a truck shipment in m^3

The cost of the remediation worker dose, $Cost_{WDose}$, can be calculated as shown in the following equation.

$$Cost_{WDose} = \$2000 \times D_R \times T \tag{17}$$

where D_R = total effective dose equivalent rate to remediation workers in units of rems/hr
T = time worked (site labor) to remediate the area in units of person-hour

The cost of worker dose usually should not be discounted because the dose is all incurred close to the time of license termination.

A cost that might fall into the other category could include the fair market rental value for the site during the time the remediation work was being performed. This cost may be added to the costs in Equation 13.

Another cost that could fall into the other category would be a remediation action that may damage an ecologically valuable area or cause some other adverse environmental impact. These impacts should be included as costs of the remediation action.

Sometimes it is very difficult or impossible to place a monetary value on an impact. A best effort should be made to assign a monetary value to the impact, because there may be no other way to compare benefits to costs. However, there may be situations for which a credible monetary value cannot be developed. In these situations, a qualitative treatment may be the most appropriate. Qualitative analyses will be evaluated on their merits on a case-by-case basis.

For performing these calculations, acceptable values for some of the parameters are shown in Table 3.1.

Table 3.1. Acceptable Parameter Values for Use in ALARA Analyses.

Parameter	Value	Reference and comments
Workplace accident fatality rate, F_W	4.2×10^{-8}/hr	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1
Transportation fatal accident rate, F_T	Trucks: 3.8×10^{-8}/km	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1
$/person-rem	$2000	NUREG/BR-0058 (Ref. 12)
Monetary discount rate, r	0.07/yr for the first 100 years and 0.03/yr thereafter, or 0.07 for buildings and 0.03 for soil	NUREG/BR-0058 (Ref. 12)
Number of years of exposure, N	Buildings: 70 yr soil: 1000 yr	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1
Population density, P_D	Building: 0.09 person/m^2 land: 0.0004 person/m^2	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1
Excavation, monitoring, packaging, and handling soil	1.62 person-hours/m^3 of soil	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1
Waste shipment volume, V_{SHIP}	truck: 13.6 m^3/shipment	NUREG-1496 (Ref. 14), Volume 2, Appendix B, Table A.1

3.1.3 Residual Radioactivity Levels that Are ALARA

The residual radioactivity level that is ALARA is the concentration, *Conc,* at which the benefit from removal equals the cost of removal. If the total cost, $Cost_T$, is set equal to the present worth of the collective dose averted in Equation 12, the ratio of the concentration, *Conc,* to the $DCGL_W$ can be determined (derivation shown in Appendix A).

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times P_D \times 0.025 \times F \times A} \times \frac{r + \lambda}{1 - e^{-(r + \lambda)N}} \qquad (18)$$

All the terms in Equation 18 are as defined previously.

If a licensee is considering restricting use of its site, it should refer to Regulatory Position 3.1.7 of this guide, which describes additional cost and benefit considerations that should be included.

Since P_D, N, and r are constants that have generic values for all locations on the site, the licensee only needs to determine the total cost, $Cost_T$, and the effectiveness, F, for a specific remediation action. If the concentration at a location exceeds *Conc*, it will be cost effective to remediate the location by a method whose total cost is $Cost_T$. Note that the concentration, *Conc,* that is ALARA can be higher or lower (more or less stringent) than the $DCGL_W$.

If a particular remediation action has been performed, there is no need to compare the final status survey results to *Conc*. If the remediation action was considered but not performed, the licensee should demonstrate in the final radiation status report that all concentrations in the survey unit are less than *Conc*.

3.1.4 Examples of Calculations

3.1.4.1 Example 1: Washing Building Surfaces. This example considers a building with cesium-137 residual radioactivity (λ = 0.023/yr). The remediation action to be considered is washing a floor of 100 m^2 area. The licensee estimates that this will cost \$400 and will remove 20% (F = 0.2) of the residual radioactivity. For buildings, generic parameters are: P_D = 0.09 person/m^2, r = 0.07/yr, and N = 70 years. Using these values in Equation 8:

$$\frac{Conc}{DCGL_W} = \frac{\$400}{\$2000 \times 0.2 \times 0.025 \times 0.09 \times 100\ m^2} \times \frac{0.07 + 0.023}{1 - e^{-(0.07 + 0.023)70}} \tag{19}$$

$$\frac{Conc}{DCGL_W} = 0.41 \tag{20}$$

To meet the ALARA requirement, the floor should be washed if the average concentration exceeds about 41% of the $DCGL_W$. This is more stringent than the dose limit. This calculation shows that washing building surfaces is often necessary to meet the ALARA requirement. If the surfaces will be washed, there is no need for the licensee to perform the ALARA evaluation or to submit the evaluation to the NRC. If the licensee decided not to wash the building surfaces, the licensee could submit this evaluation and demonstrate in the final status survey that all surfaces have a concentration below 41% of the $DCGL_W$.

3.1.4.2 Example 2: Scabbling Concrete in a Building. This example is the same as above except that it evaluates use of a scabbling tool that removes the top 1/8 inch of concrete. The licensee estimates the total cost of the scabbling will be \$5000 for the 100 m^2 floor and estimates that it will remove all the residual radioactivity so that F = 1. Using these values in Equation 18 gives:

$$\frac{Conc}{DCGL_W} = \frac{\$5000}{\$2000 \times 1 \times 0.025 \times 0.09 \times 100\ m^2} \times \frac{0.07 + 0.023}{1 - e^{-(0.07 + 0.023)70}} \tag{21}$$

$$\frac{Conc}{DCGL_W} = 0.97 \tag{22}$$

The licensee could decide to scabble depending on the concentrations present. In lieu of scabbling, the licensee could provide this analysis and demonstrate that the floor concentration is less than 0.97 $DCGL_W$.

3.1.4.3 Example 3: Removing Surface Soil. In this example, soil with an area of 1000 m^2 is found to contain radium-226 (λ = 0.000247/yr) residual radioactivity to a depth of 15 cm.

The licensee estimates that the cost of removing the soil (F = 1) will be $100,000. For soil, the generic parameters are P_D = 0.0004 person/m^2, r = 0.03/yr, and N = 1000 yr. Using these values in Equation 8 gives:

$$\frac{Conc}{DCGL_W} = \frac{\$100{,}000}{\$2000 \times 1 \times 0.025 \times 0.0004 \times 1000\ m^2} \times \frac{0.03 + 0.000247}{1 - e^{-(0.03 + 0.000247)1000}} \tag{23}$$

$$\frac{Conc}{DCGL_W} = 151 \tag{24}$$

Thus, meeting the dose limit would be limiting by a considerable margin. Based on these results, it would rarely be necessary to ship soil to a waste disposal facility to meet the ALARA requirement. The licensee could use this evaluation to justify not removing soil.

The advantage of the approach shown in these examples is that it allows the user to estimate a concentration at which a remediation action will be cost effective prior to starting remediation and prior to planning the final status survey. Thus, it is a useful planning tool that lets the user determine which remediation actions will be needed to meet the ALARA requirement.

3.1.5 When Mathematical Analyses Are Not Necessary

In certain circumstances, the results of an ALARA analysis are known on a generic basis and an analysis is not necessary. For residual radioactivity in soil at sites that will have unrestricted release, generic analyses (see Reference 14, the examples in this Regulatory Position, and other similar examples) show that shipping soil to a low-level waste disposal facility is unlikely to be cost effective for unrestricted release, largely because of the high costs of waste disposal. Therefore shipping soil to a low-level waste disposal facility generally does not have to be evaluated for unrestricted release.

Removal of loose residual radioactivity from buildings is almost always cost effective except when very small quantities of radioactivity are involved. Therefore, loose residual radioactivity normally should be removed, and if it is removed, the analysis would not be needed.

3.1.6 Additional Considerations for Ground Water

The method described above is adequate for most situations and has minimal cost for analyses. However, other factors, as described below, should be included if the site will be released under restricted conditions or if it has residual radioactivity from site operations in ground water.

If a site is released for restricted use, there would be certain costs incurred compared to release of the site for unrestricted use. These costs should be considered in the ALARA analysis. One such factor that should be considered in the ALARA analysis is the monetary value of providing the restrictions and associated financial assurance, B_{FA} (see Regulatory Position 4.2). Another factor is the potentially different property values after release of the site, B_{PV}. Differences in property values can be estimated by consulting a real estate agent that specializes in the sales of such properties. A third factor is the resources that are needed for

evaluation by the NRC of the licensee's application for restricted release submitted in the decommissioning plan, B_{NRC}. Regulatory Position 1 and the information in NUREG-1549 (Ref. 2) provide a framework for evaluating these factors when considering release options. In addition, NUREG-1549 provides information on estimating scenarios, pathways, and critical groups that should be used in estimating benefits as part of the analyses for ALARA for restricted use.

If there is residual radioactivity from site operations in ground water, it may be necessary to calculate the collective dose from consumption of the ground water. Default or generic ground-water models typically assume that potable aquifers have small volumes and cannot supply large populations. When this is the case, dose calculations for the site critical group will adequately represent the collective dose from groundwater. However, when site-specific ground-water modeling is used and the residual radioactivity is diluted in an aquifer of large volume and there is also an "existing population deriving its drinking water from a downstream supply using a downstream supply" (Ref. 9, page 39075), the collective dose for that population should be included in the ALARA calculation. In addition, the possibility of reducing the collective dose by remediation should be one of the items evaluated in many cases.

3.2 Determination of "Net Public or Environmental Harm"

In Subpart E, 10 CFR 20.1403(a) and 20.1403(e)(2)(I) address circumstances in which a licensee would be required to demonstrate that further remediation would cause net public or environmental harm. The calculation to demonstrate net public or environmental harm is a special case of the general ALARA calculation described above that compares the benefits in dose reduction to the cost of doses, injuries, and fatalities incurred. The calculation does not consider the monetary costs for performing further remediation, $Cost_R$ or the costs of waste disposal, $Cost_{WD}$. Thus, if the benefit from averted dose B_{AD} is less than the sum of the costs of workplace accidents, $Cost_{ACC}$, the costs of transportation fatalities, $Cost_{TF}$, the costs of remediation worker dose, $Cost_{WDose}$, and the costs of any environmental degradation, $Cost_{ED}$, then there is net public or environmental harm. Thus, there is net public or environmental harm if:

$$\textit{Net harm if} \quad B_{AD} < Cost_{ACC} + Cost_{TR} + Cost_{WDose} + Cost_{ED} \qquad (25)$$

In some cases it will be very difficult to assign a credible monetary value to environmental degradation. For example, environmental harm could be caused by an action such as remediation of a wetlands area. There may be no way to assign a monetary value to this action. In these cases it is acceptable to use qualitative arguments, which will be evaluated on a case-by-case basis.

3.3 Demonstration of "Not Technically Achievable"

In Subpart E, 10 CFR 20.1403(e)(2)(I) addresses circumstances in which a licensee would be required to demonstrate that further reductions in residual radioactivity are not technically achievable. Remediation of residual radioactivity is almost always technically achievable even if not economically feasible. This provision allows for special cases that may not be foreseeable; thus, specific guidance on this provision cannot be provided. Instead, NRC will evaluate licensee submittals on a case-by-case basis.

3.4 Demonstration of "Prohibitively Expensive"

In Subpart E, 10 CFR 20.1403(e)(2) addresses circumstances in which a licensee would be required to demonstrate that further reductions in residual radioactivity would be prohibitively expensive. This can be demonstrated by an analysis like the ALARA analysis described above, but using a value of $20,000 per person-rem when calculating the value of the averted dose. This value reflects the NRC's statement in the final rule on radiological criteria for license termination that the NRC believes it is appropriate to consider that a remediation would be prohibitively expensive if the cost to avert dose were an order of magnitude more expensive than the cost recommended by the NRC for an ALARA analysis (Reference 9, page 39071). However, the NRC also stated that ". . . a lower factor may be appropriate in specific situations when the licensee could become financially incapable of carrying out decommissioning safely." Thus, values lower than $20,000 per person-rem may be used when remediation actions based on $20,000 per person-rem could cause the licensee to become financially incapable of carrying out the decommissioning safely.

4. LICENSE TERMINATION UNDER RESTRICTED CONDITIONS

License termination under restricted conditions will be permitted under 10 CFR 20.1403 if all the following requirements are met:

1. The licensee can demonstrate that further reductions in residual radioactivity necessary to release the site for unrestricted use (1) would result in net public or environmental harm or (2) were not being made because the residual levels are ALARA (20.1403(a)).

2. The licensee has made provisions for legally enforceable institutional controls that would limit dose to the average member of the critical group to 25 mrem (0.25 mSv) per year (20.1403(b)).

3. The licensee has provided sufficient financial assurance to enable an independent third party to assume and carry out responsibilities for any necessary control and maintenance of the site (20.1403(c)).

4. The licensee has submitted to the NRC a decommissioning plan or a license termination plan that indicates the licensee's intent to release the site under restricted conditions and tells how advice from individuals and institutions in the community who may be affected by the decommissioning has been sought and incorporated, as appropriate, following analysis of that advice (20.1403(d)).

5. The residual radioactivity levels have been reduced so that, if the institutional controls were no longer in effect, the annual dose to the average member of the critical group would not exceed either 100 mrem (1 mSv) or, under certain conditions, 500 mrem (5 mSv). If the 500 mrem/yr (5 mSv/yr) value is used, the licensee must (1) demonstrate that achieving 100 mrem/yr is prohibitively expensive, not technically achievable, or would result in net harm, (2) make provisions for durable institutional controls, and (3) provide sufficient financial assurance to allow an independent third party to carry out rechecks of the controls at least every 5 years (20.1403(e)).

The NRC will review and evaluate the license termination plan and will solicit public input to determine whether the above requirements are satisfied. Once the NRC determines that they have been met, the NRC license is terminated and the NRC no longer regulates or oversees the

site, except in the circumstances indicated in 10 CFR 20.1401(c). Specifically, § 20.1401(c) indicates that the NRC could require additional cleanup after license termination if it determines that, based on new information, the criteria in Subpart E of 10 CFR Part 20 for release of a site were not met and residual radioactivity remaining at the site could result in a significant threat to public health and safety. Except in these specific circumstances, NRC will not be involved in the continued functioning of the institutional controls while they are in effect.

In some instances a licensee planning license termination with restricted conditions under an approved decommissioning plan or license termination plan may find, during remediation, that the site can be cleaned up to a level that would not require restricted conditions. In this case there is no need to submit an amended plan. The licensee should submit the final status report with the survey results that demonstrate that the site meets the criteria for unrestricted release. Conversely, a licensee who had planned unrestricted release may find during remediation that unrestricted release is not practical. In this instance, the licensee should submit as soon as possible an amended decommissioning plan or license termination plan proposing license termination with restricted conditions.

The restricted conditions should be limited to the smallest portion of the site that is appropriate. However, all areas that will be subject to restricted conditions should be contained within one or occasionally two areas. Complicated checkerboard patterns of areas with restricted conditions should be avoided.

4.1 Legally Enforceable Institutional Controls

This section describes the legally enforceable institutional controls that can be used to meet the requirements of 10 CFR 20.1403(b) and (e). Institutional controls may be based on property rights or on a government's sovereign or police powers.

Institutional controls based on property rights involve a party that owns rights that restrict the use of, or access to, the property. These types of controls are referred to in this guide as "proprietary institutional controls." Institutional controls based on property rights apply to land owned by individuals or private institutions and land owned by governments.

Institutional controls that involve a government using its sovereign or police powers to impose restrictions on citizens or sites under its jurisdiction to limit the use and occupation of privately owned lands are referred to in this guide as "governmental institutional controls." Among the more common governmental institutional controls are zoning, well-use restrictions, and building permit requirements.

At some sites institutional controls may include physical controls (e.g., fences, markers, earthen covers, radiological monitoring, and the maintenance of those controls). Physical controls alone do not meet the requirement in 10 CFR 20.1403(b) for legally enforceable institutional controls because they lack a mechanism for legal enforcement. Physical controls and their maintenance can be used to meet the requirement in 10 CFR 20.1403(b) only when they are used in combination with an instrument that permits legal enforcement of the physical control.

4.1.1 Proprietary Institutional Controls on Privately Owned Lands

Proprietary institutional controls on privately owned land should have the characteristics indicated here.

- The restrictions should (1) be enforceable against any owner of the affected property and any person who subsequently acquires the property or acquires any rights to use the property, (2) be enforceable by parties, other than the landowner, who have the legal authority to enforce the restriction, (3) be developed based on considerations of how durable the controls need to be, (4) include provisions to replace the party with authority to enforce the restriction, (5) indicate actions the party with authority to enforce the restrictions should take, (6) remain in place for the duration of the time they are needed, (7) have appropriate funds set aside if funds are necessary, and (8) be appropriately recorded, including in the deed and in land records, as appropriate.

- The applicability and effectiveness of the restrictions at a particular site will depend on State and local law in the jurisdiction of the site. Therefore, in developing restrictions, the licensee should refer to the property law of the particular State in which the land is located to ensure that the particular instrument selected will accomplish its intended purpose. In addition, the restrictions should be reviewed and their validity affirmed for their locality by a professional knowledgeable in local land-use laws.

4.1.1.1 **Enforcement of Restrictions on Present and Future Landowners**. The institutional control should be such that the owner of the affected property (the possessor of the land) can be compelled to abide by the terms of the use restriction. Restrictions should also be binding on future owners (possessors) of the land (i.e., they should "run with the land").

4.1.3.2 **Parties with Authority To Enforce Restrictions**. The party with the right to restrict the land's use and the responsibility to enforce the restriction should be someone other than the owner or possessor of the land in question. This means that the landowner would not be able to impose a restriction on its own property simply by filing documentation in the land records. The party (or parties) with authority to enforce the restrictions should have knowledge, capability, willingness, and the legal authority to do so, and should be appropriate for the specific situation. Depending on the situation, the parties with authority to enforce the restrictions could include State or local governments that have responsibility for public health and safety, or could include organizations such as civic organizations, local community groups, and conservation organizations; adjacent landowners; and other persons potentially impacted.

Factors to consider when naming a party with authority to enforce the restrictions should include how durable the controls need to be (see Item 3 below) and other relevant factors necessary for determining an appropriate party for enforcing the restriction over the time the restrictions would remain in place (e.g., prior existence, revenues, ability to carry out necessary actions).

4.1.1.3 **Need for Durable Controls**. An important consideration in determining the acceptability of an institutional control is that it be durable enough to provide an appropriate level of protection of public health and safety for the amount of residual radioactivity remaining on the site. Specifically, in addition to requiring that the institutional controls function to limit the dose to 25 mrem/yr in 10 CFR 20.1403(b), Subpart E also contains (in 10 CFR 20.1403(e)) two levels of protection based on potential exposure if the institutional controls become ineffective. Based on those two levels, the institutional controls and the parties enforcing the controls should be selected as follows.

- If the annual dose to the average member of the critical group would not exceed 100 mrem (1 mSv) if the institutional controls were no longer in effect, a private individual,

organization, or State or local government may be chosen as the party responsible for enforcing the institutional control.

- If the annual dose could exceed 100 mrem (1 mSv) but be less than 500 mrem (5 mSv), if the institutional controls were no longer in effect, 10 CFR 20.1403(e) requires that a more durable institutional control be used. To meet the requirement in 10 CFR 20.1403(e), an institutional control that involves government ownership of land would be generally acceptable or an institutional control on privately owned land with a State or local government as the party responsible for enforcing the restriction could also be acceptable depending on the circumstances at the site.

4.1.1.4 **Replacement of Parties with Authority To Enforce Controls.** There should be a provision to replace the party with authority to enforce the restriction if that party is no longer willing or able to enforce the restriction.

4.1.1.5 **Activities of Parties with Authority To Enforce Controls.** The restriction should clearly indicate the actions that the parties with authority to enforce the restrictions must take to keep the restrictions functioning (e.g., monitoring of deed compliance, control and maintenance of physical barriers).

4.1.1.6 **Duration of Time for Controls.** The restrictions should remain in place for the duration that they are needed. The duration may be a definite specified duration or an indefinite duration. Definite durations are for a specified number of years (for example, the number of years until radiological decay or other processes have reduced the concentration to a level corresponding to an annual dose to the average member of the critical group of less than 25 mrem (0.25 mSv) without the restrictions). Indefinite durations might end when some measurable event has occurred (for example, when natural processes have adequately reduced the risk of exposure to the residual radioactivity). The conditions that would end the restriction should be clearly stated, and the procedures for canceling or amending the restriction should be readily available. There should be no provisions in the restriction or in the land use law of the local jurisdiction that would cause the restrictions to end while they are still needed to protect the public.

4.1.1.7 **Corrective Actions.** The restrictions should identify corrective actions to be taken in case the restrictions need to be broken. For example, a no-excavation restriction may need to be broken if a water main under the site bursts and must be repaired.

4.1.1.8 **Funds for Enforcement of Controls.** Funds set aside for activities related to enforcement of restrictions by the parties responsible for enforcing the restrictions should be appropriate for the restriction used. In general, this should be:

- When physical controls are used, they generally require periodic inspection, surveys, control, or maintenance to ensure that the physical controls continue to function as planned. For example, fences and earthen covers normally require maintenance. Therefore, assurance that funds are available for those activities would normally be necessary. Regulatory Position 4.2 of this guide describes methods for estimating fund amounts.

- Deed restrictions on privately owned land are normally self-maintaining and thus would not require funds to be set aside or other financial assurance to be provided. Inspection

of the property to ensure that the restrictions are being complied with should involve minimal costs and would not, in most cases, involve setting aside specific funds.

4.1.1.9 Records. The information about the restriction should contain at least (1) a legal description of the property affected, (2) the name or names of the current owner or owners of the property as reflected in public land records, (3) identification of the parties who can enforce the restriction (i.e., own the rights to restrict use of the land), (4) the reason for the restriction, (5) a statement describing the nature of the restriction, limitation, or control created by the restriction, (6) the duration of the restriction, (7) permission to install and maintain physical controls, if any are used, and (8) the location of a copy of the final radiation status report that is available for public inspection. The information indicated should be recorded on the deed and on land records.

4.1.1.10 Examples of Proprietary Institutional Controls on Privately Owned Land. Examples of proprietary institutional controls to impose land-use restrictions on the affected property are provided below. The permissibility and effectiveness of a specific restriction will depend on the State or local laws governing the site.

Easements: An easement is a nonpossessory interest in another's land, generally entitling the easement holder to use the land or to control its use. A negative easement is the right to restrict the landowner's or possessor's use of the burdened land.

Restrictive Covenants.: A restrictive covenant is a private agreement between landowners, created by contract that either prescribes uses or imposes restrictions.

Equitable Servitudes. An equitable servitude is a form of land use restriction that limits future uses of property. For example, an equitable servitude could state that land could not be used for residences, could not be used for farming, or wells for drinking water are not permitted on the property.

Reverter Clauses: This restriction is a clause in the deed by which the property reverts to a former owner or some other party if it is ever used in a prohibited way.

4.1.2 Proprietary Institutional Controls on Government-Owned Land

In this situation, the government would actually own the land being restricted. For government ownership to exist, the licensee's land could already be government-owned (e.g., State university or Federal medical facility) or the licensee could transfer ownership of the land to the government before license termination.

The NRC will generally accept government ownership of land as a method to enforce controls on land use and to meet the legally enforceable institutional control requirements in 10 CFR 20.1403(b) and (e). This acceptability is based on the dual considerations that the government as the property owner can, based on its property rights, restrict the use of, or access to, the property and that a government owner is more likely than a private owner to act on behalf of its citizens in protecting their health. The following characteristics usually apply to government ownership of land.

- **Need for Durable Controls.** Government ownership will generally be acceptable when the dose to an average member of the critical group could exceed 100 mrem (1 mSv) per year (but be less than 500 mrem (5 mSv) per year) if the institutional controls were no longer in effect.

- **Duration of Controls**. The restrictions should remain in place for the entire time they are needed.

- **Funds for Enforcement of Controls**. Government ownership of land, unless physical barriers are used, would not normally require establishing financial assurance.

- **Documentation**. When government ownership of the land is used, the nature of the controls and restrictions on the land should be clearly stated in a publicly available legal record.

4.1.3 Institutional Controls Based on Sovereign or Police Powers
Institutional controls that are based on sovereign or police powers generally consist of zoning or other restrictive requirements on privately owned land.

The permissibility and effectiveness of governmental controls at a particular site will depend on the applicable State and local law. Therefore, zoning and other restrictive requirements should be reviewed and their validity affirmed by a professional knowledgeable in local land-use laws. In general, governmental controls should have characteristics similar to those for proprietary controls, except as specifically noted for deeds, and should include the following.

4.1.3.1 Enforcement of Controls on Present and Future Landowners. The restrictions or zoning provisions should be binding on present and future owners of the land.

4.1.3.2 Activities of the Enforcing Party. The government agency imposing the zoning or restriction should assume responsibility for enforcing the restriction.

4.1.3.3 Duration of Controls. The restrictions should remain in place for the entire time that they are needed.

4.1.3.4 Funds for Controls. If a government has normal zoning requirements, requires building permits, or requires permits for wells, financial assurance to support those activities would not be expected.

4.2.3.5 Documentation. The restrictions or zoning requirements must be clear to current and future owners of the land, local and State governments, and others, as appropriate, through public documents, notification, placement in land records, etc. Such documentation should include an indication of the activities allowable and the residual radioactivity remaining on site.

4.1.3.6 Examples of Governmental Controls. Examples of governmental controls to impose land-use restrictions on the affected property are provided below. The controls that are used should be chosen based on the characteristics listed above.

- **Zoning**. Zoning is a legal designation placed on land by a local government that restricts the types of uses on a particular property. Overlay zoning consists of zones drawn on a municipality's existing zoning map that provides protection not explicitly stated under existing zoning requirements. Since zoning is subject to change, zoning generally should be used in combination with other restrictions.

- **Government Restrictions.** Governments, most often local, can place restrictions on private property prohibiting or limiting use. Such government-imposed restrictions could include prohibiting construction of wells for water use, restricting the use of other potential water supplies, issuing permits for certain activities including use of wells for drinking water or construction or use of buildings, and establishing county or State ordinances and property law regulations.

4.2 Financial Assurance for Control and Maintenance of the Site

According to 10 CFR 20.1403(c), licensees must provide financial assurance sufficient to enable an independent third party to assume and carry out responsibilities for any necessary control and maintenance of the site. Financial assurance mechanisms that are acceptable to the NRC for providing this assurance are also listed in 10 CFR 20.1403(c).

4.2.1 Control and Maintenance of a Site

The purpose of the requirement in 10 CFR 20.1403(c) is to provide sufficient funds to carry out any necessary control and maintenance of the site so that the work could be performed by the independent third party if necessary (e.g., if the site landowner is unwilling or unable to perform such activities). Control and maintenance of a site does not necessarily have to be carried out by an independent third party. For example, the site landowner (who may be the former licensee), if capable, may carry out such activities. The site landowner could be paid from the financial assurance funds provided for performing the work, if appropriate. An arrangement for control and maintenance should have the following characteristics.

4.2.1.1 Selection of the Party. The party to control and maintain the site may be the former licensee, the landowner, a governmental agency, an organization, a corporation or company, or occasionally a private individual. The regulations specifically permit a government custodian or government owner of a site to control and maintain the site. The party should be capable of carrying out its responsibilities, should not have a conflict of interest, and should be commensurate with the nature of the restrictions in place. The party could be a contractor to the party who holds the rights to restrict use of the property. For example, an engineering company could be the party if earthen barriers were the restriction.

4.2.1.2 Replacement of the Party. There should be a mechanism to replace the party if that becomes necessary. Replacement may be by specified in the agreement with the conditions under which a government or the courts can replace the party.

4.2.1.3 Established Arrangement. There should be an arrangement or contract with a party to carry out any actions necessary to maintain the controls so that the annual dose to the average member of the critical group does not exceed 25 mrem (0.25 mSv). For example, if a party will periodically inspect and maintain an earthen cover, a contract to perform this work should be in place prior to the license termination.

4.2.1.4 Time Period. The arrangement or contract should be for as long a time as is feasible, and there should be provisions for renewing or replacing the contract to be consistent with the duration of the restrictions.

4.2.1.5 Oversight. The arrangement should include oversight of the party by a government or the courts.

4.2.1.6 Authority To Perform the Work. The party may be authorized to either perform the necessary work to maintain the controls or to contract for the performance of the work. The party would need the authority to contract for the necessary work, review and approve the adequacy of the work performed, replace contractors if necessary, and authorize payment for the work.

4.2.1.7 Authority To Hold the Funds for Decommissioning. The party generally should not hold the funds itself so that there can be a check on the performance of the party (i.e., the party should not serve as the provider of financial assurance (e.g., escrow agent, trustee, issuer of letter of credit)). However, if the party is a government, the licensee may elect to allow the government to hold the funds.

4.2.1.8 Records. All records of the official actions of and financial payments made by the party should be open to public inspection.

4.2.1.9 Periodic Site Checks. When a license is terminated under the provisions of 10 CFR 20.1403(e)(2), the party also has the responsibility to perform periodic checks of the site no less frequently than every 5 years (as required by 10 CFR 20.1403(e)(2)(iii)) to ensure that the institutional controls continue to function. The periodic checks should include an onsite inspection to verify that prohibited activities are not being conducted. A review of the deed to ensure that the deed restrictions are still in place is not usually necessary, but the review should be performed if there is any cause to believe that the restrictions are not still properly part of the deed.

4.2.2 Financial Assurance Mechanisms

Financial assurance mechanisms that are acceptable to the NRC staff for paying for any necessary control and maintenance of the site are listed in 10 CFR 20.1403(c). The mechanisms are (1) funds placed into an account segregated from the licensee's assets and outside the licensee's administrative control, (2) a surety method, insurance, or other guarantee method, or (3) a statement of intent by Federal, State, or local government licensees or an arrangement deemed acceptable by a governmental entity when the governmental entity assumes custody and ownership of a site. Section 20.1403(c) refers specifically to the financial assurance requirements for decommissioning in 10 CFR 30.35(f)(1), (f)(2), and (f)(4), respectively, as providing further description for what is required of each of the mechanisms listed above.

Guidance on the financial assurance mechanisms for decommissioning that are required by 10 CFR 30.35, including review checklists and recommended wording for the mechanisms, is contained in Regulatory Guide 3.66, "Standard Format and Content of Financial Assurance Mechanisms Required for Decommissioning Under 10 CFR Parts 30, 40, 70, and 72" (Ref. 15). Because 10 CFR 30.35 and 20.1403(c) have common basic requirements, the provisions in Regulatory Guide 3.66 can be adapted to financial assurance mechanisms for control and maintenance of a site during restricted use after license termination. In using the review checklists and recommended wording in Sections 3 and 4, respectively, of Regulatory Guide 3.66, however, terms pertinent to decommissioning, for example "licensee," "funds needed for decommissioning," and "facility name," etc., should be replaced with terms such as "site landowner," or "financing the controls after license termination."

The financial assurance funding for the controls may be included in the decommissioning financial assurance instrument or may be a separate instrument. The provider of the financial

assurance should permit public access to records on financing for the controls and maintenance. These records should be available for inspection by the public for 25 years.

4.2.3 Amount of Financial Assurance

Considerations related to physical barriers, their design, maintenance needed, and the amount of funds to be set aside, depend on the amount of radioactivity remaining, the radionuclides involved, the characteristics of the residual radioactivity, and site-specific exposure scenarios, pathways, and parameters. In general, deed restrictions on privately owned lands are normally self-maintaining and the amount of funds necessary for maintenance of deed restrictions would be minimal. These restrictions normally would not require financial assurance to provide control and maintenance.

For funds placed into an account segregated from the licensee's assets and outside its administrative control, the financial assurance fund may be assumed to earn a real (i. e., inflation adjusted, after tax) rate of return of 2% per year. The rationale for the value of 2% per year is taken from the proposed rule, "Financial Assurance Requirements for Decommissioning Nuclear Power Reactors" (62 FR 47588, September 10, 1997, Ref. 16). Because the return is after inflation, the annual costs need not be escalated for future inflation. Therefore, if perpetual control and maintenance were planned, the financial assurance funding would be 50 times the first year annual cost, C_0. If control and maintenance were planned for N years, the financial assurance funding amount would be the present worth of annual costs C_0 for N years:

$$\textit{Funding required} = C_0 \times 50\,(1 - e^{-0.02N}) \qquad (1)$$

4.3 Seeking Public Advice on Institutional Controls

Subpart E of 10 CFR Part 20 requires that public input on the institutional controls proposed by the licensee be sought at the following stages in the decommissioning process.

- **During Licensee Development of the Decommissioning Plan or LTP**. Licensees, as part of their planning for restricted use, are required by 10 CFR 20.1403(d) to seek advice from individuals and institutions in the community who may be affected by the decommissioning. The rationale for this requirement (as stated in Reference 9) is that the licensee's direct involvement regarding diverse community concerns and interests can be useful in developing effective institutional controls, and this information should be considered and incorporated as appropriate into the decommissioning plan or LTP before it is submitted to the NRC for review. This section of the guide provides guidance on complying with 10 CFR 20.1403(d).

- **During NRC Review of the Decommissioning Plan or LTP**. Once the decommissioning plan or LTP is submitted to the NRC, the NRC reviews the licensee's plans for license termination, including the institutional controls proposed to restrict site use. As part of NRC's review process, under 10 CFR 20.1405, the NRC must notify and solicit comments from the public regarding the proposed licensee action. Significant and appropriate public involvement in NRC's review process will take place at this time. Because it is the NRC's, not the licensee's, responsibility to carry out this action, this guide does not provide guidance to licensees in this area.

In order to comply with 10 CFR 20.1403(d),to ensure that the fundamental performance objectives of institutional controls are met, licensees who plan to release a site under restricted conditions will do the following.

- Seek advice on the whether the provisions for institutional controls will (1) provide reasonable assurance that annual doses will not exceed 25 mrem (0.25 mSv), (2) be enforceable, and (3) not impose undue burdens on the community.

- Seek advice from representatives of a broad cross-section of individuals and institutions in the community who may be affected by the decommissioning (affected parties).

- Provide an opportunity for a comprehensive, collective discussion on the issues.

- Provide a publicly available summary of the results of all such discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues.

- Describe in the decommissioning plan or LTP how advice from the affected parties has been sought and incorporated, as appropriate, following analysis of that advice.

4.3.1 Advice To Be Sought

As required by 10 CFR 20.1403(d)(1), the advice to be sought is whether the institutional controls proposed by the licensee will:

- Provide reasonable assurance that the total effective dose equivalent from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year.

- Be enforceable.

- Not impose undue burdens on the local community or other affected parties.

- Be backed by sufficient financial assurance for any necessary control and maintenance of the site by an independent third party.

4.3.2 Seeking Advice from Affected Parties

4.3.2.1 Identifying the Affected Parties. The licensee should first identify the affected parties. According to 10 CFR 20.1403(d)(2), the licensee must provide for participation by representatives of a broad cross-section of community interests who may be affected by the decommissioning. Affected parties may include:

- Any State, local, or Federal government agency, other than the NRC, that has jurisdiction or responsibilities with respect to the site to be decommissioned.

- Local community, civic, labor, or environmental organizations with an interest in the decommissioning, and whose members would be affected by the decommissioning.

- Adjacent landowners whose property abuts the site or portions of the site to be released under restricted conditions.

- Any Indian tribe or other indigenous people who have relevant treaty or statutory rights that may be affected by the decommissioning of the site.

4.3.2.2 Methods for Seeking Advice. The licensee should establish a method for seeking advice from the affected parties on the adequacy of the institutional controls and the sufficiency of financial assurance. It is desirable for the licensee to meet with the NRC staff to describe its intended methods for seeking advice from affected parties prior to beginning this activity in order to ensure that the proposed method will be acceptable to the NRC staff.

In obtaining input from affected parties, licensees should convene a site-specific advisory board (SSAB). If creation of an SSAB is not appropriate for a particular situation, the licensee may consider satisfying the performance objectives listed in Regulatory Position 4.3 of this guide by seeking advice directly from the affected parties without the use of an SSAB. The general rationale for using SSABs or other methods is as follows.

- **Use of SSABs.** In general, the NRC considers that convening an SSAB should be the starting point in providing for public involvement because an SSAB is the most effective way to ensure that the licensee considers the diversity of views in the community. Small group discussions can be a more effective mechanism than written comments or large public meetings for articulating the exact nature of community concerns, determining how much agreement or disagreement there is on a particular issue, and facilitating the development of acceptable solutions to issues. Also, the type of close interaction resulting from a small group discussion could help in developing a credible relationship with the community in which it is operating.

  It is important to note that the SSAB does not have to be a new group formed specifically for the decommissioning. Any group that can perform the functions of an SSAB may be considered to be an SSAB. Thus, if an existing or established group in the community has enough participation by the affected parties and can effectively perform the functions of the SSAB, that group may be used by the licensee as the SSAB.

- **Use of Other Methods for Seeking Advice.** The use of an SSAB may not be appropriate in all situations, for example, if a broad cross-section of the community clearly has insufficient interest or wishes to defer its involvement to a State or local governing body. If the licensee does not plan to convene an SSAB, it is desirable for the licensee to meet with the NRC staff to justify why an SSAB is not being convened and to describe its intended method for obtaining public input to satisfy the performance objectives. Such a meeting should take place prior to beginning this effort in order to ensure the proposed method will be acceptable to the NRC.

4.3.2.3 Convening a Site-Specific Advisory Board. Licensees should use the following guidance in establishing and convening an SSAB.

- The licensee should solicit members to serve on the SSAB. Membership should reflect the full range of the affected parties' interests by selecting representatives from the affected parties to present the views of the organization or interest that they represent. Government agencies and other organizations should be able to nominate their own representatives to the SSAB. Invited participants should be informed of the objectives of the SSAB. The SSAB normally consists of about 8 to 10 members.

- Members of the SSAB should agree to meet their responsibilities as a condition of membership. In general, NRC regulations require that the decommissioning plan be submitted within 12 months after notifying the NRC that the site will be decommissioned. The licensee is responsible for meeting this requirement. Therefore, the licensee is responsible for ensuring that the SSAB is meeting a schedule that will allow the licensee to submit the plan within the required time. If the board does not meet its responsibilities, the licensee should evaluate and discuss with the SSAB any problem and how to resolve it.

- The SSAB members should be selected as soon as practical after the licensee notifies the NRC of its intention to decommission and terminate the license.

- The licensee should provide reasonable administrative support for SSAB activities and access to licensee studies and analyses that are pertinent to the proposed decommissioning.

- To avoid the appearance of a conflict of interest, members of the SSAB usually are not paid by the licensee. However, reimbursement for expenses incurred is acceptable.

- The licensee should establish a schedule for the work of the SSAB that allows the licensee to obtain advice from the SSAB, incorporate the advice into the decommissioning plan or LTP as appropriate, and submit the decommissioning plan or LTP within the time required by NRC regulations. The schedule should include submittal of the SSAB's advice, allowing sufficient time for the licensee to analyze the advice and describe in the decommissioning plan or LTP how the advice was incorporated, as appropriate.

- The licensee should propose a charter and operating procedures for the SSAB's consideration. The charter and operating procedures should address the advice to be sought and the characteristics of an SSAB.

- The SSAB should (1) select a chairperson, (2) adopt a charter and operating procedures, (3) work with the licensee to identify and obtain information needed in its evaluation process, (4) hold meetings open to the public, provide for a comprehensive, collective discussion of the issues, and allow the opportunity for public comment at the meetings, (5) respond to concerns and questions raised by the public, making the results publicly available, (6) provide advice to the licensee on the topics listed in Regulatory Position 4.3.1.4 and on any other topics the licensee wants discussed, (7) abide by the schedule established by the licensee to meet NRC requirements, and (8) ensure that a publicly available summary of the results of all discussions, including descriptions of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues, is developed to support the meeting.

- SSAB meetings should be open to the public with adequate public notice (at least two weeks in advance) of the location, time, date, and agenda for the meetings. Consideration should be given to print, electronic, and web site notification methods. The licensee should inform the NRC of SSAB meetings and distribution of information made at SSAB meetings because these meetings and distributions may cause the public to contact the NRC.

- A summary of the results of all collective discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues, should be made publicly available.

4.3.2.4 Other Methods for Seeking Public Advice on Institutional Controls. If a licensee indicates that an SSAB is not appropriate or feasible and an SSAB is not convened, the licensee is still required by 10 CFR 20.1403(d) to seek advice on the topics listed in Regulatory Position 4.3.1 from representatives of a broad cross-section of community interests, including governmental institutions with jurisdiction and responsibilities, who may be affected by the decommissioning (affected parties). The licensee must also conduct a comprehensive collective discussion of the issues. The method used for interacting directly with the public and seeking such public advice should have the following characteristics.

1. The affected parties should be informed of the decommissioning and informed that their advice is being sought. The methods and efforts that can be used initially to inform the public can include, as appropriate for the specific site,

    - Information in mass media, for example, articles, advertisements, and public service announcements in newspapers, television, and radio.
    - Web sites or other related technologies.
    - Flyers distributed in the neighborhood or mailings to individual residents close to the site.
    - Letters or telephone contacts with government agencies and local community, civic, and labor organizations.
    - Presentations at public meetings.

2. The licensee should clearly indicate to the affected parties the matters on which advice is being sought with sufficient clarity to obtain meaningful input.

3. The initial information provided to interested affected parties should describe the decommissioning process, characterize in basic terms the nature and extent of residual radioactivity at the site, and provide pertinent information about the licensee's request for license termination under restricted conditions. Information should be provided early enough to allow sufficient time for review by the affected parties. The initial information and any subsequent long, complex studies should be provided at least 30 days before the meeting. While there should be as much time provided as practical, it is acceptable for short simple supplemental information to be provided with very little time for review.

4. The licensee should establish a method for receiving advice from the affected parties. There should always be a method to receive written comments. The licensee should also hold public meetings to obtain oral comments. There may also be a method to obtain comments electronically, such as by e-mail or through a web site. Comments received should be available for public inspection.

5. The licensee should hold at least three public meetings for discussion of the issues. The licensee should inform the NRC of public meetings and the information distributed at the meetings because these meetings and distributions may cause the public to contact the NRC.

6. A summary of the results of all collective discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues, is to be made publicly available.

4.4 Alternative Criteria for License Termination

For certain difficult sites with unique decommissioning problems, 10 CFR 20.1404 includes a provision by which the NRC may terminate a license using alternative dose criteria. The NRC expects the use of alternative criteria to be confined to rare situations. This provision was included in 10 CFR 20.1404 because the NRC believed that it is preferable to codify provisions for these difficult sites in the rule rather than require licensees to seek an exemption process outside the rule.

Under 10 CFR 20.1404, the NRC may consider terminating a license under alternative criteria that are greater than 25 mrem (0.25 mSv) per year (but less than 100 millirems (1 mSv) per year), but the NRC limits the conditions under which a licensee could apply to the NRC for, or be granted use of, alternative criteria to unusual site-specific circumstances subject to the following provisions.

- The licensee has provided assurance that public health and safety will continue to be protected and that it is unlikely that the dose from all man-made sources combined, other than medical, would be more than 100 millirems (1 mSv) per year. A licensee proposing to use alternative criteria would have to provide a complete and comprehensive analysis of such possible sources of exposure.

- The licensee would employ, to the extent practical, restrictions on site use for minimizing exposure at the site, using the provisions for institutional controls and financial assurance in 10 CFR 20.1403 and in Regulatory Positions 4.1 and 4.2 of this guide.

- The licensee would reduce doses to ALARA levels, based on a comprehensive analysis of risks and benefits of all viable alternatives.

- The licensee would seek advice from affected parties regarding the use of alternative criteria at the site. In seeking this advice, the licensee would conduct the activities for seeking advice required by 10 CFR 20.1404(a)(4), including providing for participation by a broad cross-section of community interests who may be affected by decommissioning; providing an opportunity for a comprehensive collective discussion of the issues related to the alternative criteria by the affected parties; and providing a publicly available summary of all such discussions. As part of this process, the licensee would submit a decommissioning plan or LTP indicating how advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and addressed.

- The licensee would obtain the specific approval of the NRC for the use of alternative criteria. The NRC would make its decision after considering the NRC staff's recommendations that would address any comments provided by the Environmental Protection Agency and any public comments submitted regarding the decommissioning plan or LTP.

It is desirable for a licensee who has a difficult site with unique decommissioning problems to meet with the NRC staff to describe its interest in, and plans for, using alternative

criteria. Because these situations are expected to be rare, this guide does not contain detailed guidance on the use of alternative criteria. In the licensee's meeting with the NRC, it is expected that the NRC would provide additional site-specific guidance on possible sources of ionizing radiation to be included, the nature of the complete and comprehensive analysis of sources and of ALARA, considerations related to specific areas of the site that might be included, the restrictions that would be considered practical and that therefore should be employed, the licensee's plans for seeking advice from affected interests in the community on the alternative criteria, and the information to be submitted in the decommissioning plan or LTP.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees on the NRC staff's plans for using this regulatory guide.

This draft guide has been distributed for comment to encourage public participation in its development. It represents the current position of the NRC staff, which is subject to change after the review of the public comments. Comments received during the public comment period on this guide will be considered in developing the final guide.

Until the final guide is published, this document represents the best available guidance, and you may use it when preparing requests for licensing actions. The staff recognizes that the rulemaking referenced in this regulatory guide is complex, and the positions stated in this guide may not be applicable to all licensees. In addressing the positions discussed in this guide, licensees are encouraged to contact the staff with questions on implementation. After the final guide is published, the NRC staff will use the final guide in its review of requests for licensing actions.

REFERENCES

1. M.C. Daily et al., "Working Draft Regulatory Guide on Release Criteria for Decommissioning: NRC Staff's Draft for Comment," NUREG-1500, USNRC, August 1994. (NUREG-1500 has been superseded by DG-4006, therefore it is available to the public only through the NRC Public Document Room.)[1]

2. USNRC, "Guidance on Using Decision Methods for Dose Assessment To Comply with Radiological Criteria for License Termination," NUREG-1549 (Draft dated March 13, 1998 is available as Enclosure 2 to SECY-98-051 in the PDR.)

3. USNRC, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," NUREG-1575, December 1997.

4. USNRC, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys," NUREG-1505, June 1998.

5. E.W. Abelquist et al., "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions," NUREG-1507, USNRC, June 1998.

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9. USNRC, "Radiological Criteria for License Termination," Final Rule, *Federal Register,* Volume 62, page 39058 (62 FR 39058), July 21, 1997.

10. Executive Order 12866, "Regulatory Planning and Review," in Title 3 of the 1993 Compilation of the Code of Federal Regulations, page 638, January 1, 1994.

11. Office of Management and Budget, "Economic Analysis of Federal Regulations under Executive Order 12866," January 11, 1996. (Available on the Internet at http://www1.whitehouse.gov/WH/EOP/OMB/html/miscdoc/riaguide.html)

12 USNRC, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," NUREG/BR-0058, Revision 2, November 1995.

13. USNRC, "Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy," NUREG-1530, December 1995.

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[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

14. USNRC, "Final Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities," NUREG-1496, Vol. 1, July 1997.

APPENDIX A

Derivation of Equation 18 To Calculate the Concentration of Residual Radioactivity that Is ALARA

The ALARA analysis compares the monetary value of the desirable effects (benefits) of a remediation action (e.g., the monetary benefit of collective averted dose) with the monetary value of the undesirable effects (e.g., the costs of waste disposal). If the benefits of a remediation action would exceed the costs, the remediation action should be taken to meet the ALARA requirement.

If benefits > costs, the remediation action should be taken (1)

The primary benefit from a remediation action is the collective dose averted in the future, i.e., the sum over time of the annual doses received by the exposed population. Assume:

1. A site has an area with residual radioactivity at concentration, *Conc*.
2. The concentration equivalent to 25 mrem (0.25 mSv)/yr ($DCGL_W$) for the site has been determined (for soil or for building surfaces, as appropriate).
3. The residual radioactivity at a site has been adequately characterized so that the effectiveness of a remediation action can be estimated in terms of the fraction *F* of the residual radioactivity that the action will remove.
4. The peak dose rate occurs at time 0 and decreases thereafter by radiological decay.

The derived concentration guideline ($DCGL_W$) is the concentration of residual radioactivity that would result in a total effective dose equivalent to an average member of the critical group of 0.25 mSv (25 mrem)/yr. Acceptable methods of calculating the $DCGL_W$ are discussed in Regulatory Position 1. Therefore, the annual dose *D* to the average member of the critical group from residual radioactivity at concentration *Conc* is:

$$D = 0.025\ rem/yr \times \frac{Conc}{DCGL_W} \qquad (2)$$

If a remediation action would remove a fraction, *F*, of the residual radioactivity present, the annual averted dose to the individual, $AD_{individual}$, is:

$$AD_{individual}\ (rem/yr/person) = F \times 0.025\ rem/yr \times \frac{Conc}{DCGL_W} \qquad (3)$$

The annual collective averted dose, $AD_{collective}$, can be calculated by multiplying the individual averted dose, $AD_{individual}$, by the number of people expected to occupy the area, *A*, containing the residual radioactivity. The number of people in the area containing the residual radioactivity is the area, *A*, times the population density, P_D, for the site. Thus:

$$AD_{collective} = F \times 0.025 rem/yr \times \frac{Conc}{DCGL_W} \times A \times P_D \quad (4)$$

The annual monetary benefit rate at time 0, B_0, from the averted collective dose in dollars per year can be calculated by multiplying the annual collective averted dose, $AD_{collective}$, by \$2000/person-rem (\$200,000/person-sievert) (Reference A1):

The total monetary benefit of averted doses can be calculated by integrating the

$$B_0 = \$2000 \times F \times 0.025\ rem/yr\ \frac{Conc}{DCGL_W} \times A \times P_D \quad (5)$$

annual benefit over the exposure time in years, considering both the present worth of future benefits and radiological decay. It is OMB and NRC policy to use the present worth of both benefits and costs that occur in the future (References A1 and A2).

The equation for the present worth, PW_B, of a series of constant future annual benefits, B (in dollars per year), for N years at a monetary discount rate of r (per year) using continuous compounding is:

$$PW_B = B \times \frac{e^{rN} - 1}{r\, e^{rN}} \quad (6)$$

The continuous compounding form of the present worth equation is used because it permits an easy formulation that includes radiological decay. If the annual benefit rate, B, is not constant but is decreasing from an original rate, B_0, because of radiological decay, the radiological decay rate acts like an additional discount rate that can be added to the monetary discount rate of decrease so that the present worth of the annual benefits PW_B becomes:

$$PW_B = B_0 \times \frac{e^{(r+\lambda)N} - 1}{(r + \lambda)\, e^{(r+\lambda)N}} \quad (7)$$

Dividing the numerator and denominator of the right hand term by $e^{(r+\lambda)N}$ yields:

$$PW_B = B_0 \times \frac{1 - e^{-(r+\lambda)N}}{r + \lambda} \quad (8)$$

As $N \rightarrow \infty$, Equation 8 has the limit:

$$PW_B = B_0 \times \frac{1}{r + \lambda} \quad (9)$$

When the discount rate, r, is zero and the radiological decay rate is very small so that $r + \lambda \cdot 0$, and Equation 8 has the limit:

$$PW_B = B_0 \times N \tag{10}$$

The total benefit from the collective averted dose, B_{total}, is the present worth of the annual benefits. B_{total} can be calculated by combining Equations 6 and 8:

$$B_{total} = \$2000 \times F \times 0.025 \times \frac{Conc}{DCGL_W} \times A \times P_D \times \frac{1 - e^{-(r+\lambda)N}}{r+\lambda} \tag{11}$$

Now consider the total cost of a remediation action, $Cost_T$. The costs included in $Cost_T$ are (1) the direct cost of the remediation action itself, $Cost_{RA}$, (2) the cost of waste disposal including its shipping cost, $Cost_{WD}$, (3), the monetary costs of workplace accidents during the remediation, $Cost_{ACC}$, (4) the monetary costs of transportation accidents during the shipping of waste, $Cost_{TF}$, (5) the monetary value of the dose that remediation workers receive, $Cost_{WDose}$, and (6) other costs as appropriate for the specific site, $Cost_{other}$. Thus,

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{other} \tag{12}$$

What is of interest in this derivation is the concentration, $Conc$, at which the benefit, B_{total}, equals the total cost, $Cost_T$. Thus, in Equation 11, $Cost_T$ can be substituted for B_{total}, and then Equation 11 can be solved for the concentration, $Conc$, relative to the $DCGL_W$ or $Conc/DCGL_W$ as in Equation 13.

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times F \times 0.025 \times P_D \times A} \times \frac{r + \lambda}{1 - e^{-(r+\lambda)N}} \tag{13}$$

Equation 13 can be used to determine the concentration in an area for which a remediation action should be taken to meet the ALARA criterion. The equation appears complicated, but can be solved in a few minutes with a hand-held calculator, and it only has to be done once for each type of remediation action at a site. P_D, N, and r are constants. Generic values for P_D and N are given in Reference A3 or may be determined on a site-specific basis. Values for r are given in References A1 and A2. The only site-specific information that the licensee needs is the total cost, $Cost_T$, and the effectiveness, F, for each remediation action being evaluated.

REFERENCES

A1. NUREG/BR-0058, Revision 2, "Regulatory Analysis Guidelines of the U. S. Nuclear Regulatory Commission," November 1995.

A2. Office of Management and Budget, "Economic Analysis of Federal Regulations under Executive Order 12866," January 11, 1996 (Available on the web at http://www1.whitehouse.gov/WH/EOP/OMB/html/miscdoc/riaguide.html).

A3. NUREG-1496, "Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities," 1997.

REGULATORY ANALYSIS

A Regulatory Analysis was prepared for the final rule on Radiological Criteria for License Termination, which was published in the *Federal Register* on July 21, 1997 (62 FR 39058). This rule is the regulatory basis for this guide, so a separate regulatory analysis has not been prepared for this guide. A copy of the Regulatory Analysis is available for inspection or copying for a fee in the NRC's Public Document Room at 2120 L Street NW., Washington, DC. Single copies of the Regulatory Analysis, to the extent of supply, may be obtained by written request from the Radiation Protection and Health Effects Branch Secretary, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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