NUREG-1757
Supplement 1

Consolidated NMSS Decommissioning Guidance

Updates to Implement the License Termination Rule Analysis

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001

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COMMENTS ON DRAFT REPORT

Any interested party may submit comments on this report for consideration by the NRC staff.

Comments may be accompanied by additional relevant information or supporting data. Please specify the report number NUREG-1757, Supplement 1, draft, in your comments, and send them by December 30, 2005, to the following address:

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ABSTRACT

In September 2003, the U.S. Nuclear Regulatory Commission (NRC) published a three-volume NUREG report, NUREG-1757, "Consolidated NMSS Decommissioning Guidance." NUREG-1757 provides guidance on: planning and implementing license termination under the License Termination Rule (LTR) in 10 CFR Part 20, Subpart E; complying with the radiological criteria for license termination; and complying with the requirements for financial assurance and recordkeeping for decommissioning and timeliness in decommissioning of materials facilities.

This draft supplement to NUREG-1757 is the first of periodic updates to the three volumes of NUREG-1757, to reflect current NRC decommissioning policy. NUREG-1757, Supp. 1, provides draft guidance for addressing the following LTR Analysis issues, which were explored by the NRC staff in Commission papers: restricted use and institutional controls; onsite disposal of radioactive materials; scenario justification based on reasonably foreseeable land use; intentional mixing of contaminated soil; and removal of material after license termination. It also provides new and revised guidance to address several other issues. This draft is published for public comment. Please submit comments by December 30, 2005.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in this NUREG are covered by the requirements of 10 CFR Parts 19, 20, 30, 33, 34, 35, 36, 39, 40, 51, 70, 72, and 150 which were approved by the Office of Management and Budget, approval numbers 3150–0044, 0014, 0017, 0015, 0007, 0010, 0158, 0130, 0020, 0021, 0009, 0132, and 0032.

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FOREWORD

In September 2003, the U.S. Nuclear Regulatory Commission (NRC) published a three-volume NUREG report, NUREG-1757, "Consolidated NMSS Decommissioning Guidance." This report provides guidance on: planning and implementing license termination under the License Termination Rule (LTR), in 10 CFR Part 20, Subpart E; complying with the radiological criteria for license termination; and complying with the requirements for financial assurance and recordkeeping for decommissioning and timeliness in decommissioning of materials facilities. This draft supplement is the first of periodic updates to the three volumes of NUREG-1757, to ensure it reflects current NRC decommissioning policy.

NUREG-1757 consists of the following documents:

Vol. of NUREG-1757	Title	Status
Vol. 1	Decommissioning Process for Materials Licensees	Revision 1; issued September 2003
Vol. 2	Characterization, Survey, and Determination of Radiological Criteria	Final; issued September 2003
Vol. 3	Financial Assurance, Recordkeeping, and Timeliness	Final; issued September 2003
Supp. 1	Updates to Implement the License Termination Rule Analysis	Draft for public comment; issued September 2005

This draft includes new and revised decommissioning guidance that addresses some of the LTR Analysis implementation issues, previously analyzed by the staff in SECY-03-0069 (Results of the LTR Analysis, May 2, 2003) and SECY-04-0035 (Results of the LTR Analysis of the Use of Intentional Mixing of Contaminated Soil, March 1, 2004). Regulatory Issue Summary 2004-08 (Results of LTR Analysis) was issued on May 28, 2004 to inform stakeholders of the LTR Analysis, the Commission direction to date on how the LTR Analysis issues can be addressed, the schedule of future actions, and the opportunities for stakeholder comment. Part of the Commission direction to the staff was to revise existing decommissioning guidance to address the LTR Analysis issues. This draft supplement to NUREG-1757 addresses that direction, and also includes new and revised guidance on other issues.

As part of this guidance development, the staff discussed the LTR Analysis issues and solicited input and suggestions from stakeholders at the NRC decommissioning workshop in April 2005. The workshop provided an opportunity for stakeholders to provide early input into the development of guidance on these issues, before NRC staff formally issued the draft guidance for public comment. The staff also met with NRC's Advisory Committee on Nuclear Waste (ACNW) on June 15, 2005, to obtain early input from an ACNW working group on the key issues. To obtain State assistance in drafting this guidance, the staff established a State working group, consisting of representatives from the Organization of Agreement States, the Conference of Radiation Control Program Directors, and NRC. The stakeholders who attended the workshop, the ACNW members and consultants, and the State working group members

provided valuable input, which the staff has considered and addressed, as appropriate, in developing this draft.

The staff also received comments and recommendations on other parts of the guidance and general decommissioning improvements, which the staff plans to address at a later time.

Draft NUREG-1757, Supp. 1, is published for public comment only, and this guidance is not intended for use until it is published in final form. However, the general approaches and options for the LTR Analysis issues that have been approved by the Commission (SRM-SECY-03-0069 and SRM-SECY-04-0035) can be and have been pursued by the staff and licensees. This draft is being distributed for comment to encourage public participation in its development. Please submit comments, as described in the comment solicitation on the back of the title page, by December 30, 2005. Staff will consider comments received after that time, if practical. After consideration of public comments on this draft, the staff plans to revise Volumes 1, 2, and 3 of NUREG-1757 to incorporate this guidance by September 2006.

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The team also thanks Terry L. Johnson, consultant to NRC, for assistance regarding engineered barriers.

GLOSSARY

Affected parties. Representatives of a broad cross-section of individuals and institutions in the community or vicinity of a site that may be affected by the decommissioning of the site.

Durable institutional controls. A legally enforceable mechanism for restricting land uses to meet the radiological criteria for license termination (10 CFR 20, Subpart E). Durable institutional controls are reliable and sustainable for the time period needed.

Footprint. The portion of a site undergoing decommissioning, which is comprised of all of the areas of soil containing residual radioactivity, where intentional mixing is proposed to meet the release criteria.

Legacy site. An existing decommissioning site that is complex and difficult to decommission for a variety of financial, technical, or programmatic reasons.

Reasonably foreseeable land use. Land use scenarios that are likely within 100 years, considering advice from land use planners and stakeholders on land use plans and trends.

Robust engineered barrier. A man-made structure that is designed to mitigate the effect of natural processes or human uses that may initiate or accelerate release of residual radioactivity through environmental pathways. The structure is designed so that the radiological criteria for license termination (10 CFR 20, Subpart E) can be met. Robust engineered barriers are designed to be more substantial, reliable, and sustainable for the time period needed without reliance on active ongoing maintenance.

I INTRODUCTION

Draft Supplement 1 to NUREG-1757 provides guidance for addressing the following LTR Analysis issues, which were explored in SECY-03-0069 and SECY-04-0035: restricted use and institutional controls; onsite disposal of radioactive materials; scenario justification based on reasonably foreseeable land use; intentional mixing of contaminated soil; and removal of material after license termination. It also provides new and revised guidance to address several other issues. Chapter II of this Supplement includes revised decommissioning guidance for use of institutional controls at restricted use and alternate criteria sites under the LTR. Chapter II also includes revised guidance on the risk-informed graded approach for engineered barriers. Although the topic of engineered barriers was not analyzed in the staff's LTR Analysis, the staff decided to revise this guidance to supplement the restricted use guidance, further risk-inform NRC's decommissioning program, and provide more flexibility.

Chapter III contains additional guidance regarding the acceptable options for onsite disposal of radioactive materials under 10 CFR 20.2002. Chapter IV provides revised guidance on selection and justification of exposure scenarios based on reasonably foreseeable future land use (previously referred to as "realistic exposure scenarios"). Chapter V provides new guidance on options for the use of intentional mixing of contaminated soil. Chapter VI provides additional detail on removal of material after license termination, which is a follow-up to the LTR Analysis issue on the relationship between the LTR and the current case-by-case approach for release of solid materials.

Chapter VII of this draft includes other proposed changes and additions to the existing guidance in NUREG-1757, which were identified or proposed by NRC staff or by stakeholders. Chapter VII includes guidance and information on Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP); statistical mean value of measured radionuclide concentrations to be used in dose assessments; how the decommissioning guidance is risk-informed; returning, canceling, or reducing financial assurance instruments; and the Memorandum of Understanding Between the U.S. Environmental Protection Agency (EPA) and NRC.

The introduction to each chapter of this draft explains in further detail what changes are being proposed to the decommissioning guidance. These introductions also discuss what existing sections of NUREG-1757 are impacted by the proposed changes in this draft, or if the proposed changes are new, where the new guidance could be added to NUREG-1757. Table I.1 lists the sections of NUREG-1757 that are impacted by the proposed revisions in this draft.

Table I.1 Proposed Changes in Draft NUREG-1757, Supp. 1

Chap. No.	Topics in draft Supp. 1	Revised Sections of NUREG-1757		
		Vol. 1	Vol. 2	Vol. 3
II	Restricted Use, Institutional Controls, and Engineered Barriers	Sect. 17.7 Sect. 17.8 App. M	Sect. 3.5	—
III	Onsite Disposal of Radioactive Materials	NEW Sect. 15.12	—	—
IV	Scenario Justification Based on Reasonably Foreseeable Land Use	—	Chap. 5 Sect. I.3 App. M	—
V	Intentional Mixing of Contaminated Soil	Sect. 17.1.3 NEW Sect. 15.13	—	—
VI	Removal of Material After License Termination	NEW Sect. 15.11.1	Sect. G.1.1 Sect. G.3	—
VII	Other Issues and Changes	Sect. 5.2	Sect. 2.1 NEW Sect. 2.8 Sect. 4.0 App. D App. E Sect. I.2	NEW Chap. 8

How to Read and Review this Draft

Proposed revisions in this draft are displayed in two ways:

1. **Revisions to existing guidance**

   If there are specific changes to the existing guidance in NUREG-1757, additions to the existing text are highlighted, and deletions to existing text are shown in strikeout text. In some sections of revised text, figures and tables that were not changed were left out of this draft for brevity.

2. **New guidance or proposed replacement of existing guidance**

   If the proposed guidance in this draft is mainly new guidance to be added to NUREG-1757 or if it is a major rewrite of an existing section in NUREG-1757, highlight and strikeout text is not used. Instead, margins are marked with a wide line. The chapter introduction will note if this is the case and will also discuss where the new guidance will be placed in NUREG-1757.

The page headers that are used delineate the chapters of this draft and the existing volume and section in NUREG-1757 in which changes are proposed.

Note to Readers

NRC staff either made changes to existing text or added entirely new sections to NUREG-1757. Sections from NUREG-1757, Vols. 1–3, are shown in Times New Roman, 12 point font, as originally published.

Deleted text is shown with the following attribute:
~~strikeout~~.

In sections and chapters where minor changes to existing text were made, new text is shown with the following attribute:
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In sections and chapters that were added or required extensive revisions, the highlighted attribute is omitted, and new or extensively revised text is shown with the following attribute:
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II RESTRICTED USE, INSTITUTIONAL CONTROLS, AND ENGINEERED BARRIERS

The License Termination Rule (LTR) Analysis, SECY-03-0069 (NRC 2003), included discussions on restricted use, institutional controls, and the LTR's risk-informed graded approach for institutional controls. Following the LTR Analysis, the associated Regulatory Issue Summary (RIS) 2004-08 (NRC 2004) also provided a discussion of these issues. As a result of those two documents, the NRC staff revised the following sections of NUREG-1757, Vol.1, Rev. 1, to incorporate the Commission approved options related to restricted use and institutional controls and to include guidance on the risk-informed graded approach:

- Section 17.7, "Restricted Use and Alternate Criteria"
- Section 17.8, "Obtaining Public Advice on Institutional Controls"
- Appendix M, "Overview of the Restricted Use and Alternate Criteria Provisions of 10 CFR Part 20, Subpart E"

  In the following draft guidance for Sections 17.7 and 17.8 and Appendix M, new or revised text is shown highlighted, and deleted text is shown as strikeout text.

The engineered barrier topic was not explored in the LTR Analysis and was not explicitly mentioned in the Commission's direction on the LTR Analysis. However, the topic is important to restricted use sites and compliments institutional controls. The existing guidance in NUREG-1757 was an initial attempt to address this topic, but more work was needed to describe a risk-informed graded approach for engineered barriers to be consistent with the risk-informed graded approach for institutional controls. Therefore, the staff revised this guidance, in accordance with the Commission's direction to further risk-inform the program and provide more flexibility, and proposed revisions to the following section of NUREG-1757, Vol. 2:

- Section 3.5, "Use of Engineered Barriers"

  The following draft guidance on engineered barriers is intended as a complete replacement of the existing guidance in Section 3.5 of Vol. 2, so highlighting is not used.

II.1 Restricted Use and Institutional Controls

The staff revised the decommissioning guidance for use of institutional controls at restricted use and alternate criteria sites under the LTR. Specifically, the staff intended the revisions to clarify the LTR's risk-informed graded approach, which describes a framework for identifying lower risk and higher risk sites and the appropriate type of institutional controls for each.

The revisions also include descriptions of the two new options for restricted use, with NRC long-term oversight: (1) long-term control (LTC) license (a new type of possession-only license that functions as a legally enforceable institutional control) and (2) legal agreement and restrictive covenant (LA/RC). For restricted use sites that cannot arrange legally enforceable institutional controls, these two options provide for legally enforceable institutional controls and, if needed, durable institutional controls under the LTR. Although these two options differ from the original LTR concept that NRC would not have an oversight role after decommissioning and

license termination, both options were approved by the Commission and are consistent with the LTR.

The staff based its revisions on the interim guidance for the LTC license at the Shieldalloy site. Some minor changes were made to the interim guidance based on feedback from the NRC decommissioning workshop and input from the State working group and ACNW working group. For the LA/RC option, the staff used the general format of the guidance for the LTC license but made a number of modifications to reflect the characteristics of the LA/RC option.

The staff also clarified the guidance on seeking advice from affected parties on institutional controls. The staff developed guidance on the types of information the licensee could share with the affected parties, to promote understanding of the restricted use decommissioning plans and allow the affected parties to provide advice on the various aspects of the institutional controls. The changes to this part of the guidance are based on experience with decommissioning sites that are pursuing restricted use.

The staff revised the topic of site maintenance and long-term monitoring in Section 17.7 of Vol. 1, Rev. 1, to describe a risk-informed approach for both monitoring and maintenance and to link this guidance to the new guidance on engineered barriers.

The staff also added a discussion to Appendix M of Vol. 1, Rev. 1, on the risk-informed graded approach, concepts related to both new NRC options for institutional controls, and the total system approach for sustaining protection.

The staff specifically is seeking comment on the partial restricted release approach of keeping an entire site (that contains both restricted and unrestricted use portions) together under single ownership and an LTC license. This approach is discussed in the following revisions to Section 17.7.2.2.1 and Section M.3.5 of Vol. 1, Rev. 1.

II.2 Engineered Barriers

The revised guidance on engineered barriers describes a risk-informed graded approach and provides an example for erosion control. This approach includes the use of robust engineered barriers. Guidance also is given for the analysis process and technical basis. In addition, the staff incorporated information on degradation mechanisms and potential levels of functionality and uncertainty.

Changes to
NUREG-1757, Vol. 1, Rev. 1,
Section 17.7, "Restricted Use and Alternate Criteria"

17.7 RESTRICTED USE AND ALTERNATE CRITERIA

17.7.1 OVERVIEW

NRC staff should review the information supplied by the licensee to determine if the description of the activities undertaken by the licensee is adequate to allow the staff to conclude that the licensee has complied with the applicable requirements of 10 CFR 20.1403 or 10 CFR 20.1404, for those licensees who intend to request termination of their radioactive materials licenses using either the restricted use or alternate criteria provisions of 10 CFR Part 20, Subpart E.

If the licensee is requesting license termination under restricted use in 10 CFR 20.1403, this information should include: a demonstration that the licensee qualifies for license termination under 10 CFR 20.1403(a); a description of the institutional controls the licensee has instituted or plans to institute at the site; a description of the activities undertaken by the licensee to obtain advice from the public on the proposed institutional controls and the results of these activities; a demonstration that the potential doses from residual radioactive material at the site will not exceed the limits in 10 CFR 20.1403 and are ALARA; and a description of the financial assurance mechanism required under 10 CFR 20.1403(c).

If the licensee is requesting license termination using the alternate criteria provisions of 10 CFR 20.1404, the information should include: a description of the institutional controls the licensee has instituted or plans to institute at the site; a demonstration that doses from residual radioactive material at the site will not exceed the limits in 10 CFR 20.1404(a)(1); a description of the restrictions on site use the licensee has provided to comply with 10 CFR 20.1404(a)(2); a demonstration that the potential doses are ALARA; and a description of the activities undertaken by the licensee to obtain advice from the public and the results of these activities.
10 CFR 20.1403 requires that licensees obtain advice from institutions and individuals that may be affected by the decommissioning on specific issues related to institutional controls and financial assurance. However, 10 CFR 20.1404 provides for a much broader discussion of the issues associated with the use of alternate criteria, and as such, licensees must obtain (1) advice on essentially any issue associated with the use of alternate criteria and (2) a description of the financial assurance mechanism required under 10 CFR 20.1403(c).

The LTR established a system of controls to sustain protection at restricted use or alternate criteria sites. This approach is described in Appendix M. The total system includes the following six elements: (1) legally enforceable institutional controls; (2) engineered barriers; (3) monitoring and maintenance; (4) independent third party oversight; (5) sufficient funding; and (6) maximum limits on dose (i.e., “dose caps”) if institutional controls fail. While elements 1, 3, 4, 5, and 6 are required by the LTR, element 2 (engineered barriers) is not required but could be used to mitigate adverse processes (e.g., infiltration or erosion) so that the dose criteria of the LTR can be met (see Section 3.5). The licensee should describe how it proposes to apply the total system approach to its specific site.

The licensee should describe how it has used the risk-informed graded approach (described in Appendix M of this Volume and Section 3.5) to select the appropriate institutional controls and engineered barriers for decommissioning under restricted use or alternate criteria, so that restrictions and engineered barriers are most effectively targeted and are based on duration and magnitude of the hazard. This approach is flexible and uses risk insights from dose assessments to tailor site-specific restrictions and engineered barriers that would prevent potential disruptive land uses or natural processes important to compliance with the dose criteria. Appendix M also describes how institutional controls combine with other elements, such as engineered barriers, to form a total system to sustain protection.

If a licensee cannot establish acceptable institutional controls or independent third party arrangements, the licensee may propose one of the two new options involving NRC: an NRC Long-Term Control (LTC) license or an NRC Legal Agreement and Restrictive Covenant (LA/RC). Both of these options are described in Appendix M of this Volume and are summarized below. These options should be considered as a last resort, even though they are available for use under the conditions described in Appendix M.

The LTC license option is a possession-only license that would be used to satisfy the LTR requirement for legally enforceable and durable (if needed) institutional controls. The conditions of the LTC license would require the licensee to maintain restrictions on site use and any necessary monitoring, maintenance, and reporting. NRC would use inspections and enforcement, if needed, to assure that the licensee's controls and other activities are effective.

The LA/RC option is a combination of a legal agreement and restrictive covenant that provides a legally enforceable and durable institutional control, with the NRC having an enforcing role. Under the LA/RC option, the current licensee or site owner and NRC enter into a legal agreement on the restrictions and controls needed for license termination under restricted conditions. The legal agreement includes using a restrictive covenant, which outlines the restrictions on site use and any necessary maintenance, monitoring, or reporting. In accordance with the legal agreement, the licensee or site owner is required to record the restrictive covenant with the appropriate recordation body in the jurisdiction where the site is located, before the site is released under restricted conditions.

The LTC license is preferred over the LA/RC option for institutional controls involving NRC, as NRC licensing and enforcement is a proven approach, and the LA/RC option has some limitations: it has not been implemented by the NRC or legally tested; NRC's ability to enforce the LA/RC depends on the laws of the jurisdiction where the site is located; and it would be more difficult for NRC to enforce the LA/RC, in comparison to the LTC license. The LTC license is preferred for sites that will require more complex monitoring or maintenance activities. Complex monitoring or maintenance activities could include maintenance of an engineered barrier and groundwater or radiological monitoring activities, which require the site owner to have necessary knowledge, expertise, or technical abilities to carry out these activities and comply with all provisions of the LTC license. If the restrictions on site use or monitoring and reporting activities are simpler, the LA/RC may be an appropriate institutional control option.

Simpler restrictions or activities related to the restrictions could include the site owner responding to an annual NRC inquiry as to how the site is being used or allowing the NRC to conduct a periodic inspection of the site. The LA/RC option provides flexibility for a formerly licensed site where the current owner does not want to become a licensee or for current licensees where the owner may want license termination.

Figure 17.1 (below) illustrates the steps in the process of selecting an option for restricted use or alternate criteria, types of institutional controls, and the use of NRC options for restricted use decommissioning. Consultations with NRC during this process are encouraged. The steps in this process are described below.

1. Determine if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to the average member of the critical group that does not exceed 0.25 mSv/y (25 mrem/y) without institutional controls to restrict future site use (10 CFR 20.1402).

   Yes: Evaluate the unrestricted use option.

   No: Go to step 2.

2. Determine if the site meets the following "eligibility" criteria for restricted use in 10 CFR 20.1403(a): The licensee has demonstrated that further reductions in residual radioactivity at the site to meet the unrestricted use criteria in 10 CFR 20.1402 would (1) result in net public or environmental harm, or (2) are not being undertaken because the residual radioactivity levels are ALARA.

   Yes: Site is eligible for restricted use. Go to step 3.

   No: Site does not meet eligibility criteria for restricted use. Reduce residual radioactivity so that site meets criteria for unrestricted use or eligibility criteria for restricted use.

3. Determine if the residual radioactivity that is distinguishable from background radiation results in a TEDE to the average member of the critical group that does not exceed 0.25 mSv/y (25 mrem/y) with institutional controls to restrict future site use (10 CFR 20.1403).

   Yes: Site is eligible for restricted use. Go to step 4.

   No: Evaluate the alternate criteria option, including going to step 4 for selecting institutional controls under alternate criteria requirements.

4. Determine if the site is a lower or higher risk site, based on the following criteria and as shown in Table M.1 of this Volume, to select appropriate institutional controls.

   Lower risk sites:

   Shorter hazard duration: shorter dose persistence or shorter radionuclide half-life (less than 100 years).

   Lower hazard level: calculated dose is less than the public dose limit of 1.0 mSv/y (100 mrem/y) assuming institutional controls are not in place.

   Higher risk sites:

   Longer hazard duration: longer dose persistence or longer radionuclide half-life (more than 100 years).

   Higher hazard level: calculated dose is 1.0–5.0 mSv/y (100–500 mrem/y) assuming institutional controls are not in place.

5. Determine if the licensee was able to establish other types of durable, legally enforceable institutional controls or independent third party arrangements.

   Yes: Licensee must comply with all other LTR requirements in 10 CFR 20.1403(b), (c), (d), (e) or 10 CFR 20.1404, for license termination under restricted conditions or alternate criteria.

   No: Licensee should submit letter from Federal, State, or local government declining ownership or control responsibility and go to step 6 to select NRC options for institutional controls.

6. Determine the appropriate NRC option for providing an institutional control.

   LTC license option is the preferred option and should be used if:

   — Substantial restrictions, monitoring, or maintenance require special expertise (e.g., groundwater monitoring, use of an engineered barrier);

   — Maintaining single ownership of a site with both restricted use and unrestricted use areas is warranted to sustain future ownership and long-term protection of the site.

   LA/RC option may be used if:

   — Current licensee or formerly licensed site owner requests use of the LA/RC rather than the LTC license, demonstrates that the LA/RC option would be effective and legally

enforceable by NRC in the jurisdiction where the site is located, and demonstrates that the LA/RC would be a significant benefit to the licensee/owner and affected parties; and

— Restrictions, monitoring, or maintenance activities are simple and do not require maintaining special expertise (e.g., annual letter certifying restrictions are in place, fence repair, sign replacement).

Demonstrate compliance in the decommissioning plan (DP): After the above steps are completed and an option is selected, the licensee would incorporate the option into its decommissioning plan and demonstrate compliance with all other applicable LTR requirements.

Before preparation and submittal of the decommissioning plan to NRC, the licensee is encouraged to contact NRC, or the appropriate Agreement State authority, to discuss the various decommissioning options, including those for restricted use and alternate criteria sites.

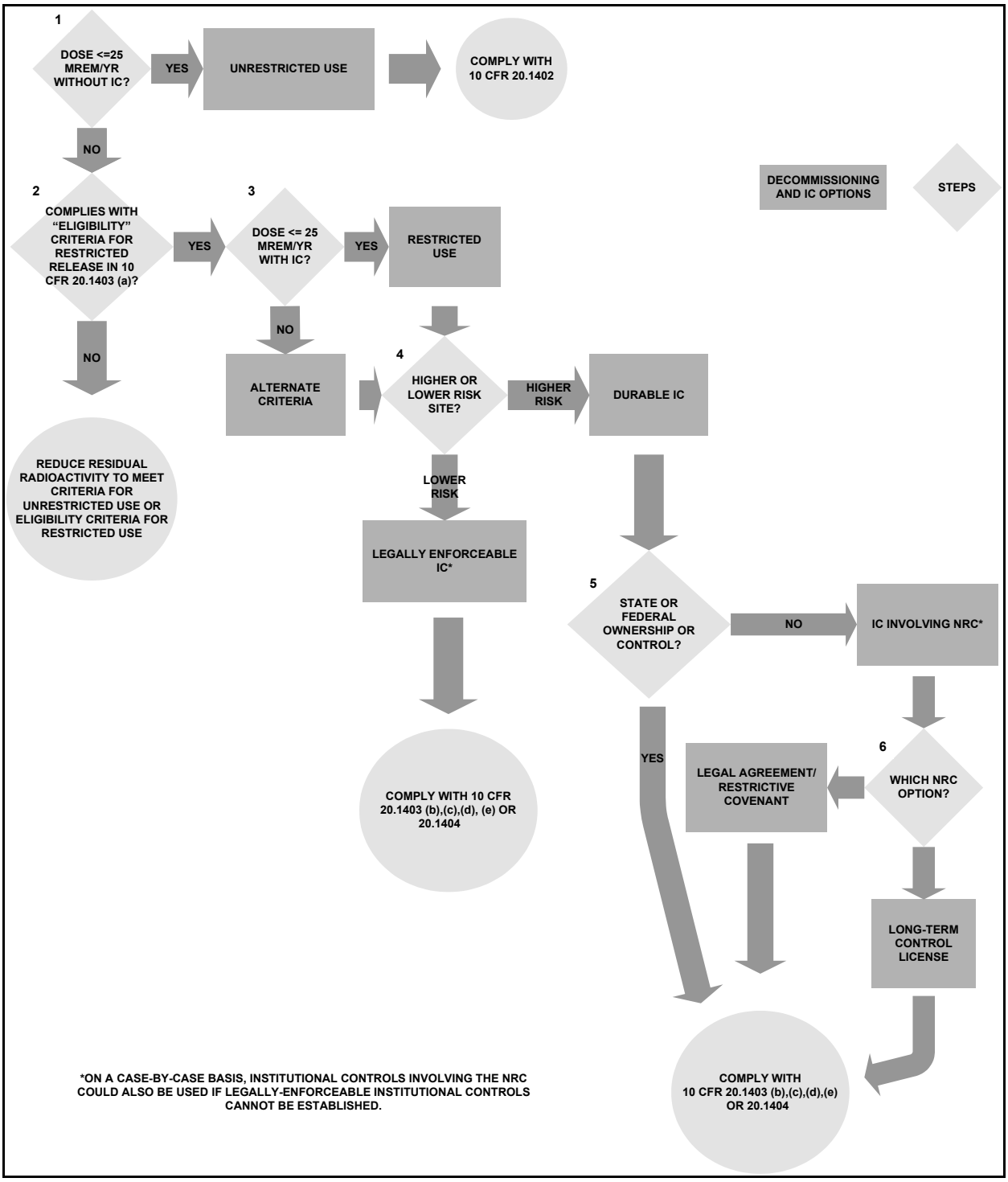

Figure 17.1 Selection Process for Decommissioning Options and use of Institutional Controls

17.7.2 RESTRICTED USE

17.7.2.1 Eligibility Demonstration

The purpose of the review of the licensee's demonstration that it is eligible to request release of the site, under the provisions of 10 CFR 20.1403, is to verify that the licensee has demonstrated that further reductions in residual radioactivity at the site to meet the unrestricted release criteria in 10 CFR 20.1402 would: (1) result in net public or environmental harm; or (2) are not being undertaken because the residual radioactivity levels are ALARA.

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to fully understand how the licensee has concluded that reducing radioactivity to the unrestricted use levels in 10 CFR 20.1402 would result in net public or environmental harm or are not being undertaken because the residual radioactivity levels are ALARA. The staff's review should verify that the following information is included in the licensee's demonstration that it is eligible for requesting license termination under the provisions of 10 CFR 20.1403:

- A demonstration that the benefits of dose reduction are less than the cost of doses, injuries, and fatalities (see Volume 2 of this NUREG series); or
- A demonstration that the proposed residual radioactivity levels at the site are ALARA.

EVALUATION FINDINGS

Evaluation Criteria

If the licensee has concluded that further reductions in residual radioactivity levels would result in net public or environmental harm, the staff should verify that the licensee has accurately calculated the benefits versus costs of further remediation using the guidance in Chapter 6 and Appendix N of Volume 2 of this NUREG series. In considering the net public and environmental harm, a licensee's evaluation should consider the radiological and nonradiological impacts of decommissioning on a person that may be impacted, as well as the potential impact on ecological systems from decommissioning activities. (See Section B.3.2 of the "Statements of Consideration" for the License Termination Rule, 62 FR 39069.)

If the licensee has concluded that further reductions in residual radioactivity levels are not required because they are ALARA, the staff should verify that the licensee has considered all of the applicable benefits and costs of further reduction of residual radioactivity and accurately

calculated the benefits and costs using the methodology described in Chapter 6 and Appendix N of Volume 2 of this NUREG series.

17.7.2.2 Institutional Controls and Engineered Barriers

The purpose of the review of the description of the institutional controls and engineered barriers the licensee has provided for the site is to determine if the licensee has made provisions for legally enforceable institutional controls that will limit the dose to the average member of the critical group to less than 0.25 mSv/y (25 mrem/y).

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to fully understand what institutional controls and engineered barriers the licensee plans to use or has provided for the site and the manner in which these institutional controls will limit doses to the average member of the critical group to 0.25 mSv/y (25 mrem/y).

The licensee should summarize the total system of controls used to provide protection and include a general description of each system element and how it contributes to protection. Elements might include institutional controls, engineered barriers, monitoring and maintenance; independent third party oversight; trust fund; and maximum limits on dose (i.e., "dose caps") assuming institutional controls fail. Refer to Appendix M of this Volume, which describes this total system approach and apply the approach for the specific site. The staff's review should verify that the following information is included in the description of institutional controls that the licensee plans to use or has provided for the site:

17.7.2.2.1 Institutional Controls

The information supplied by the licensee should be sufficient to allow the staff to fully understand what institutional controls the licensee plans to use or has provided for the site and the manner in which these institutional controls will limit doses to the average member of the critical group to 0.25 mSv/y (25 mrem/y). The staff's review should verify that the following information is included in the description of institutional controls that the licensee plans to use or has provided for the site:

Area and Type of Institutional Controls

- Area and description of the general type of institutional controls and the basis for selection, using NRC's risk-informed graded approach in Appendix M of this Volume. Using this

approach, determine if the restricted area of the site is a lower or higher risk area and the general type of institutional controls that are needed. Consider both hazard duration, based on the dose persistance and the half-life of radionuclides, as well as hazard level [i.e., less than or greater than 1.0 mSv/y (100 mrem/y)] based on dose assessments assuming controls are no longer in effect. For a simpler site, the complete area of the current site would be restricted use. For a more complex site, this approach might result in identifying unrestricted use areas where no institutional controls are required, and restricted use areas using either legally enforceable institutional controls or durable and legally enforceable institutional controls.

- A demonstration that the size of the restricted use area has been minimized. The staff considers that minimizing the size of the restricted use area would contribute to demonstrating ALARA for sites that are considering subdividing the site into unrestricted and restricted use portions. It would also result in a smaller area to control, which may make access limitations like fencing and surveillance simpler and thus more effective.

  When determining what portion of the site needs to be restricted (or how a site could be subdivided between restricted and unrestricted portions), the licensee should consider and balance the goal of minimizing the restricted area of the site (and minimizing burdens associated with restricted use) with defining the area that will ensure long-term protection. Risk insights from dose assessments (extent of residual radioactivity and how it migrates/travels through the environment) will help determine what areas need to be monitored and the location and size of the restricted area.

  However, on a case-by-case basis, a site that is kept under an LTC license and has both restricted and unrestricted use areas may need to have both areas kept together under single ownership and LTC license. This approach is preferred for a privately owned site needing long-term restrictions on use, where the restricted use area has little or no resale value and the unrestricted use area has resale value that would maintain the value for the entire site and thus sustain future ownership. For this case, show the boundaries for both the restricted use area(s) and the unrestricted use area(s). See Appendix M of this Volume for further description and justification for this approach and the flexibility for partial restricted release (i.e., release of unrestricted use areas on a case-by-case basis.)

- A description of the specific type of legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism.

  If such controls cannot be arranged, provide justification for appropriateness of using either the LTC license or LA/RC options:

  — durable institutional controls are required; and

  — licensee was unable to establish other types of legally enforceable institutional controls and independent third party arrangements (e.g., letter from the State declining responsibility).

For the LTC license, state that two specific types of institutional controls would be used. First, describe that the NRC LTC license is considered to be a specific type of legally enforceable and durable institutional control. Second, describe the licensee's responsibility to put in place and maintain a deed notice that notifies potential landowners of the LTC license requirement and the conditions of the LTC license.

Use the following criteria to decide when the LTC license or LA/RC would be appropriate:

LTC license option is the preferred option and should be used if:

— Substantial restrictions, monitoring, or maintenance require special expertise (e.g., groundwater monitoring, use of an engineered barrier);

— Maintaining single ownership of a site with both restricted use and unrestricted use areas is warranted to sustain future ownership and long-term protection of the site.

LA/RC option can be used if:

— Current licensee or formerly licensed site owner requests use of the LA/RC rather than the LTC license, demonstrates that the LA/RC option would be effective and legally enforceable by NRC in the jurisdiction where the site is located, and demonstrates that the LA/RC would be a significant benefit to the licensee/owner and affected parties; and

— Restrictions, monitoring, or maintenance activities are simple and do not require maintaining special expertise (e.g., annual letter certifying restrictions are in place, fence repair, sign replacement).

Restrictions and Controls Implemented by Licensee

- A description of the restrictions on present and future landowners;

  Describe the access and land use restrictions, based on the dose assessments assuming no controls. Identify specific access and land use scenarios that would lead to non-compliance with the dose criteria of the LTR and therefore should be prohibited (e.g., farming, construction of a residence, excavation into the cell for any purpose, or groundwater use).

  Indicate what access and land uses might be permitted (e.g., industrial, recreational, or wildlife conservation area).

  Describe what restrictions on land use would be needed to maintain effective engineered barrier performance (e.g., prohibit excavation of the cell cap and removal of cell cap material or contaminated material), as well as permitted access and land use.

Describe the licensee's activities to restrict/control access and land use, including use of fences, signs, monuments, and periodic surveillance (e.g., annual site surveillance and adverse event surveillance).

If the LTC license or LA/RC is used, all of the above should be conditions in the LTC license or LA/RC. Recognize that the licensee will need to prepare a Long-Term Control Plan that will describe the details of how the licensee will implement the LTC license conditions.

- A discussion of the durability of the institutional control(s);

  Explain how the controls selected are durable based on the risk-informed graded approach.

  Note that NRC considers both the LTC license and LA/RC to be durable institutional controls.

Duration of the Institutional Controls

- A description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s).

  For the LTC license and LA/RC, discuss that the duration of these controls is as long as needed, but could be permanent for a site with long half-life radionuclides, such as uranium and thorium. However, the LTC license would be renewed at least every 5 years. The appropriate renewal time period would be determined when establishing the LTC license for a specific site and could be adjusted in the future.

  Under the LTC license, further flexibility is provided for a licensee to request, in the future, approval for removing the residual radioactivity, terminating the license, and releasing the site for unrestricted use. For this approach, a licensee would submit a decommissioning plan for NRC review, as is currently done, and decommission the site in accordance with NRC's decommissioning regulations. NRC would assure that the site was properly decommissioned and suitable for unrestricted release, before terminating the LTC license.

Records Retention and Availability

- A description of the records pertaining to the institutional controls, how and where will they will be maintained, and how the public will have access to the records.

  For the LTC license, identify both historical and new records to be retained by the licensee that are necessary for the licensee to provide effective long-term protection. This includes the decommissioning plan, final status survey report, LTC license, long-term control plan, and all correspondence under the LTC license. Identify the location and methods used for retention of records by the licensee. Note that NRC will retain all licensing records as part of its agency

recordkeeping system and that these records will be available to the public in the future, as they are today.

For the LA/RC, identify both historical and new records to be retained by the site owner that are necessary for the site owner to provide effective long-term protection, including the decommissioning plan, final status survey report, legal agreement (site owner at time of license termination), restrictive covenant, and correspondence between NRC and the site owner. Note that NRC has the primary responsibility for maintaining records and making those available to the public, as part of its Agency recordkeeping system. In accordance with the legal agreement, the licensee or site owner would be required to record the restrictive covenant with the appropriate recordation body responsible for maintaining records related to land ownership (e.g., Registrar of Deeds) in the jurisdiction where the site is located. These recordkeeping responsibilities should be outlined in the legal agreement and restrictive covenant.

Detriments Associated With Institutional Controls

- A description of any detriments or potential drawbacks associated with the maintenance of the institutional control(s). Detriments could result from restricted use of the land, independent of the type of legal instrument used for institutional controls. Include any applicable stakeholder inputs or advice, if provided.

  For the LTC license, describe any detriments to using the LTC license option. For example, describe potential impacts on sale of property or value of property due to the NRC license or perceptions that NRC could potentially require further cleanup in the future (i.e., lack of finality).

17.7.2.2.2 Engineered Barriers

Include the information below on engineered barriers using the guidance in Section 3.5 of NUREG-1757, Volume 2.

Engineered Barrier Analyses

- Contribution of engineered barriers towards compliance, with institutional controls in place, including monitoring and maintenance
- Contribution of engineered barriers toward compliance, assuming loss of institutional controls (including monitoring and maintenance) and barrier degradation
- Analyses of human and natural disruptive processes

Technical Basis for Engineered Barrier Performance

- Design and functionality of engineered barriers, including interactive effects (both positive and negative) from the implementation of multiple barriers.
- Technical basis for design and functionality of engineered barriers
- Degradation mechanisms and sensitivity analysis
- Uncertainty in design and functionality of engineered barriers
- Suitability of numerical models
- Model support
- Quality assurance

EVALUATION FINDINGS

Evaluation Criteria

The staff should determine whether the information summarized in "Information to be Submitted," above satisfies the criteria summarized below. The application of the criteria below is dependent on the circumstances of the case. In each case, the staff should consult with the Office of the General Counsel on the application of the criteria and the sufficiency of the licensee's proposal.

A. For legally enforceable institutional controls on privately owned land:

Proprietary institutional controls on privately owned land, including LA/RC, should:

- Be enforceable against any owner of the affected property and any person that subsequently acquires the property or acquires any rights to use the property.
- Be enforceable by entities, other than the landowner, that have the legal authority to enforce the restriction. For LA/RC, the legal authority to enforce the restriction would be with the NRC.
- Be developed based on considerations of how durable the controls need to be.
- Include provisions to replace the entity with authority to enforce the restriction.
- Indicate actions the entity with authority to enforce the restrictions may take.
- Remain in place for the duration of the time they are needed.
- Have appropriate funds set aside.

- Be appropriately recorded, including in the deed and in land records, as appropriate.
- Include a legal opinion by an attorney specializing in real estate law, who is knowledgeable in the particular State and local land use laws, that demonstrates:
  - The property law of the particular State and locality in which the land is located ensures that the particular instrument selected will accomplish its intended purpose.
  - The restrictions have been reviewed and their validity affirmed for the locality.
  - The owner of the affected property (i.e., the possessor of the land) can be compelled to abide by the terms of the land use restriction.
  - The restrictions are binding on future owners (possessors) of the land (i.e., they should "run with the land").
- Include a legal opinion that the entity with the right to restrict the land's use and the responsibility to enforce the restriction has the legal authority to do so and is someone other than the owner or possessor of the land in question.
- Include a demonstration that the entity (or entities) with authority to enforce the restrictions have the knowledge, capability, and willingness to do so, and are appropriate for the specific situation.
- Include a demonstration that the institutional control is durable enough to provide an adequate level of protection of public health and safety and the environment for the amount of residual radioactivity remaining on the site. Use the risk-informed graded approach described in Appendix M of this Volume.
- Include a provision to replace the entity with authority to enforce the restriction if that entity is no longer willing or able to enforce the restriction.
- Clearly state the actions that the parties with authority to enforce the restrictions may take to keep the restrictions functioning (e.g., monitoring of deed compliance, control and maintenance of physical barriers).
- Include a demonstration that the restrictions will remain in place for the duration that they are needed, including periodic re-recording of the restrictions.
- If restrictions will end, the conditions that would end the restriction must 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.
- 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.
- Include a demonstration that the information about restrictions is recorded in the deed and in land records and will contain:

— a legal description of the property affected;

— the name or names of the current owner or owners of the property as reflected in public land records;

— identification of the parties that can enforce the restriction (i.e., own the rights to restrict use of the land);

— the reason for the restriction, the nature of the radiation hazard, including the estimated dose if institutional controls fail, and that this restriction is established as a condition of license termination by NRC pursuant to 10 CFR 20.1403;

— a statement describing the nature of the restriction, limitation, or control created by the restriction;

— the duration of the restriction;

— permission to install and maintain physical controls, if any are used; and,

— the location of copies of the important records related to the decommissioning of the site and license termination under restricted conditions.

- For LA/RC, identify the reasons that the LA/RC is an appropriate option for institutional controls, given the criteria in "Area and Type of Institutional Controls" in Section 17.7.2.2.1.

B. For legally enforceable institutional controls on government owned land:

NRC may 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). Government ownership will generally be acceptable when the dose to an average member of the critical group could exceed 1.0 mSv/y (100 mrem/y) [but be less than 5.0 mSv/y (500 mrem/y)] if the institutional controls were no longer in effect. In reviewing restrictions involving government ownership of land, NRC staff should ensure that the restriction will remain in place for the entire time they are needed and that the nature of the controls and restrictions on the land are clearly stated in a publicly available legal record. Depending on the government entity involved, consider as appropriate the items under Part A, above.

C. For 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. The permissibility and effectiveness of governmental controls at a particular site will depend on the applicable State and local law.

Institutional controls based on sovereign or police powers should:

- Include a legal opinion by an attorney specializing in real estate law who is knowledgeable in the particular State and local land use laws that verifies the following:

— Zoning and other restrictive requirements have been reviewed and their validity affirmed.

— They are binding on present and future owners of the land.

- Include a demonstration that the government agency imposing the zoning or restriction will assume responsibility for enforcing the restriction.
- Include a demonstration that the restrictions will remain in place for the entire time that they are needed or the conditions that can cause them to be changed.
- Include a demonstration that the restrictions or zoning requirements are 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, and so forth. Such documentation should include an indication of the allowable activities and the residual radioactivity remaining on site.

D. For institutional controls based on NRC LTC license:

For the LTC license, identify the reason that the LTC license is an appropriate option for durable institutional controls, given the criteria in Section 17.7.2.2.1.

17.7.2.3 Site Maintenance and Long-Term Monitoring

The purpose of the review of the information about the licensee's long-term monitoring and site maintenance program is to ensure that: (1) adequate arrangements have been made to ensure that the site will be maintained in accordance with the institutional controls described above, and that (2) the licensee has an adequate arrangement to ensure that an independent third party can assume and carry out responsibilities for any necessary control, monitoring, and maintenance of the site after NRC has terminated the license. Criteria for evaluating the licensee's mechanism to ensure that sufficient funds are available to allow an independent third party to assume and carry out responsibilities for any necessary control, monitoring, and maintenance of the site after NRC has terminated the license, are addressed in Part II of Volume 3 of this NUREG series.

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to fully understand what arrangements for long-term monitoring and site maintenance have been provided by the licensee. This should include descriptions of how the site maintenance arrangements will ensure that the site will be managed per the institutional controls described above and how an independent third party will assume and carry out responsibilities for any necessary control and maintenance of the site after NRC has terminated the license.

The licensee should describe the long-term monitoring and maintenance activities. Under the LTC license, these would be required by the license conditions. For the LA/RC option, these activities would be required by the provisions of the LA/RC. Note that a Long-Term Control Plan would be developed before license termination or before license amendment for the LTC license option, which would include the detailed plans and procedures for restrictions on access and use, long-term monitoring, and maintenance. The staff's review should verify that the following information is included in the discussion of the site maintenance program in the facility DP:

Long-term Monitoring

- A description and basis for the long-term monitoring program, using the risk-informed graded approach. This approach consists of combining the prohibited access and land uses that could lead to non-compliance from Section 17.7.3.2.1 with the human and natural disruptive processes for engineered barriers from 17.7.3.2.2 to form one list of disruptive human and natural processes, which could lead to non-compliance and should be the focus of monitoring and maintenance.

  For these disruptive processes, identify how each would be monitored, including type of monitoring (e.g., visual surveillance of fence integrity, visual surveillance for indicators of disruptive erosion such as gullies; radiological monitoring of groundwater or surface water; visual surveillance of disruptive vegetation intrusion into an engineered barrier/cover) and how each type would be used to detect indicators or precursors of the disruptive process, either in the environment surrounding the engineered barrier or the engineered barrier itself. Also, include and justify the location, frequency, and duration of monitoring. Duration of monitoring should be determined by considering several site-specific factors such as nature of disruptive processes; time needed to reduce uncertainty in barrier performance; and barrier degradation rates. Thus, duration and amount of monitoring should be risk-informed. For example, little or no long-term monitoring might be needed for lower risk sites, sites without disruptive processes important to compliance, or sites with low uncertainty in the engineered barrier performance over the time needed. In contrast, monitoring would be needed for higher risk sites, sites with disruptive processes, or if there is high uncertainty with engineered barrier performance.

Maintenance

- A description of the site maintenance program and the basis for concluding that the program is adequate to control and maintain the site.

  The following risk-informed approach should be used for determining the maintenance that is needed, which consists of identifying the disruptive process important to compliance, describing the maintenance that would provide corrective actions to mitigate the disruptive process, and how monitoring information would be used to identify the need and appropriate type of maintenance.

The risk-informed approach for maintenance also would be applied to engineered barriers, if they are used. For higher risk sites where robust barriers are designed so their performance does not rely on active ongoing maintenance, monitoring and maintenance should still be planned, particularly, for disruptive events that could lead to non-compliance or where there is higher uncertainty. This approach provides added confidence through redundancy and defense-in-depth, as described in Appendix M for the total system.

For the LTC license and LA/RC, the maintenance activities would be conditions of the LTC license or LA/RC, and the detailed plans and procedures to implement the conditions would be included in the Long-Term Control Plan.

- A demonstration that an appropriately qualified entity has been provided to control and maintain the site.

  Under the LTC license, the entity could be the licensee or a contractor to the licensee. Describe the qualifications of the personnel that are necessary to conduct the planned LTC activities.

- If the licensee plans on using a contractor, a description of the arrangement or contract with the entity charged with carrying out the actions necessary to maintain control at the site.
- If the licensee plans on using a contractor, a demonstration that the contract or arrangement will remain in effect for as long as feasible, and include provisions for renewing or replacing the contract.
- A description of the plans for corrective actions that may be undertaken in the event the institutional control(s) fail.
- A description of the plans for corrective actions that may be undertaken in the event the site maintenance and control program fails.

  Identify reasonably foreseeable events (e.g., forced entry through fences or disruption of cap material) that could cause a failure of access and land use controls. Describe the corrective actions the licensee would take and the requirement that NRC would be notified of the events and planned corrective actions.

- A description of licensee reporting to NRC and State and local officials, including an annual report and event corrective actions reports, as needed. The annual report should describe licensee surveillance and routine maintenance. Event corrective action reports would identify the adverse event that occurred and the licensee's planned corrective actions. Follow- up reports would include a summary of the results of the corrective actions taken, an analysis of lessons learned from the event, and plans to prevent similar future events from occurring.

Enforcing Institutional Controls

- A description of the entities enforcing, and their authority to enforce, the institutional control(s);

  For the LTC license, specify that NRC will have jurisdiction for oversight of licensee activities and can take enforcement actions, if needed, under its licensing authority from the AEA. NRC's general role under the LTC license is to assure that the controls are maintained and remain protective over time. Also note that NRC activities would include review, inspection, license renewal, and enforcement.

  For the LA/RC, specify that NRC is responsible for (1) assuring that the site owner is complying with the LA/RC, and (2) taking legal actions to enforce the LA and RC, if the conditions of these legal tools are not met. The LA/RC, when written for a specific site, would describe the methods and frequency in which NRC (as the enforcing party) would monitor the site to verify the effectiveness of controls. Outline how the NRC would enforce the restrictions, and if the LA or RC were breached, what steps NRC would take to restore these instruments (and the land use restrictions, monitoring, or reporting actions they contain).

- A description of the activities that the entity with the authority to enforce the institutional controls may undertake to enforce the institutional controls;

  This is not applicable for the LTC license option. Under the LA/RC option, the legal agreement and restrictive covenant should outline the activities in which NRC may undertake to enforce the controls.

- A description of the manner in which independent oversight of the entity charged with maintaining the site will be conducted and what entity will conduct the oversight.

  For the LTC license and LA/RC, the above item is not applicable, because NRC is the entity that will conduct the oversight.

- A description of the periodic site inspections that will be performed by the third party, including the frequency of the inspections.

  This is not applicable for the LTC license option. Under the LA/RC option, the legal agreement and restrictive covenant should outline any necessary details of the periodic site inspections NRC will perform, including the frequency of the inspections.

- A description of the manner in which the entity with the authority to enforce the institutional control(s) will be replaced if that entity is no longer willing or able to enforce the institutional control(s) (this may not be needed for Federal or State entities);

  For the LTC license and LA/RC, the above item is not applicable, because NRC is the enforcing party.

Sufficient Financial Assurance

For the purposes of a LTC license and LA/RC, "sufficient" financial assurance, pursuant to 10 CFR 20.1403(c), is an amount that will (1) enable an independent third party to assume and carry out responsibilities for any necessary control and maintenance of the site, (2) provide for trust fund expenses, (3) provide for NRC fees applicable to the site, and (4) provide a 25% contingency factor. The financial assurance instrument used will be a trust fund with sufficient capital to cover the cost estimate. The cost estimate, trust agreement, and the trustee must be approved by NRC.

To develop the cost estimate, refer to NUREG-1757, Volume 3, which contains guidance on developing the cost estimate for long-term site control and maintenance. Once the amount is estimated, the licensee must provide sufficient funds to produce an annual average income that covers the annual surveillance, control, and maintenance/repair costs, NRC fees, and trustee expenses. By analogy to uranium mill tailings funds, a 1% rate of return may be used by the licensee to determine the minimum funding level. This rate would contribute to the LTR requirement for sufficient funds for a site with long-lived radionuclides needing control over a long time period. It is also justified because the current licensee responsible for the contamination should fund the long-term control so that no additional costs will be passed on to future site owners/licensees.

The cost estimate should include costs for at least the following activities:

- site surveillance of access and land use restrictions;
- maintenance;
- radiological monitoring of surface and groundwater, if needed;
- reporting; and
- records retention.

For the LTC license, the cost estimate should also include NRC oversight fees. The fees given below are in 2005 dollars and should be adjusted for inflation. To adjust for inflation, use the ratio of the cost of professional staff hours found in 10 CFR 170.20. In 2005, the staff-hour cost for NMSS was $197 per hour. In 2005, NRC fees in 2005 dollars are as follows:

- a fee of $10,000 for one inspection and one report each year; and
- $20,000 every 5 years for 5 year license renewal, inspection, and report.

For the LA/RC option, the cost estimate should include the above NRC oversight fees for periodic inspections (at a frequency/interval based on site-specific considerations). The cost estimate should also include fees for NRC review of the property laws in the jurisdiction where

the site is located at the time site ownership changes (or at least every five years), to assure that the local laws still support the enforceability of the restrictive covenant.

Finally, the estimate should include reasonable trustee fees and expenses.

NUREG-1757 Volume 3 provides for contingency factor of 25% to be added to the cost estimate. This contingency should be retained to buffer against potential market losses and to provide for unexpected costs. If the contingency proves insufficient, the licensee should add funds to the trust. As a matter of fairness, particularly in light of the long term existence of the fund, if the balance substantially exceeds the amount needed to produce sufficient annual income, a provision, to return excess funds to the licensee with NRC's approval, should be included in the trust.

Under the LTC license, further flexibility is provided for a future licensee to request approval for removing the residual radioactivity, terminating the license, and releasing the site for unrestricted use. For this approach, a licensee would submit a decommissioning plan for NRC review, as is currently done, and decommission the site in accordance with NRC's decommissioning regulations. NRC would assure that the site was properly decommissioned and suitable for unrestricted release, before terminating the LTC license. The trust fund does not have to include sufficient funds to clean the site to unrestricted release; the future site owner would need to independently cover this cost.

Independent Third Party

- a description of the authority granted to the third party (including NRC under the LTC license or LA/RC options) to perform, or have performed, any necessary maintenance activities;
- unless the entity is a government entity, a demonstration that the third party is not the entity holding the financial assurance mechanism (this is not applicable for the LTC license or LA/RC options as NRC is the beneficiary of the financial assurance mechanism);
- a demonstration that sufficient records evidencing to official actions and financial payments made by the third party (including NRC under the LTC license or LA/RC) are open to public inspection.

EVALUATION FINDINGS

Evaluation Criteria

The staff should determine whether the information summarized under "Information to be Submitted," above satisfies the criteria summarized below. The application of the criteria below is dependent on the circumstances of the case. In each case, the staff should consult with the Office of the General Counsel on the application of the criteria and the sufficiency of the licensee's proposal.

The entity 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. Control and maintenance of a site does not necessarily have to be carried out by an independent third party. The entity should be capable of carrying out its responsibilities and should be appropriate given the nature of the restrictions in place. The entity could be a contractor to the entity that holds the rights to restrict use of the property. Note that government control and/or ownership is generally appropriate for higher risk sites involving large quantities of uranium and thorium contamination and for those sites where the potential dose to the public could exceed 1.0 mSv/y (100 mrem/y) if institutional controls fail. See Appendix M for the risk-informed graded approach.

The maintenance and control program includes detailed descriptions of: (1) the repair/replacement and maintenance program for the site; (2) if appropriate, an environmental monitoring program, including the duration of the monitoring, who will be informed of the results, action levels and what action will be taken if the action levels are exceeded; and (3) the mechanism to detect and mitigate the loss of site controls; the mechanism to, if necessary, inform local emergency responders of the loss of controls.

An arrangement or contract is in place 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 0.25 mSv (25 mrem). 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. The arrangement may include oversight of the entity by a government entity or the courts.

A mechanism is in place to replace the entity controlling/maintaining the site if that becomes necessary. Replacement may be specified in the agreement with the conditions under which a government, the courts, or other entity can replace the entity.

The entity is authorized to either perform the necessary work to maintain the controls or to contract for the performance of the work. The entity 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.

The entity performing the site control and maintenance should not hold the funds itself; that is to say, the entity should not serve as the provider of financial assurance (e.g., escrow agent, trustee, issuer of letter of credit). However, if the entity is a government, the licensee may elect to allow the government to hold the funds.

A demonstration that sufficient records evidencing the official actions of and financial payments made by the entity are open to public inspection.

The entity has the responsibility to perform periodic rechecks of the site no less frequently than every 5 years [if required by 10 CFR 20.1403(e)(2)(iii)] to ensure that the institutional controls continue to function. The periodic rechecks should include an onsite inspection to verify that prohibited activities are not being conducted and that markers, notices, and other physical controls remain in place. ~~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.~~

Under the LTC license option, NRC would review and renew the LTC license every five years. Under the LA/RC option, NRC would review the property laws in the jurisdiction where the site is located at the time site ownership changes (or at least every five years), to assure that the laws of the jurisdiction where the site is located still support the enforceability of the restrictive covenant.

17.7.2.4 Obtaining Public Advice

The purpose of the review of the licensee's description of activities undertaken to obtain advice from the public on institutional controls is to determine if the advice of individuals and institutions in the community that may be affected by the decommissioning has been sought, evaluated, and as appropriate, incorporated into the licensee's decommissioning decisions, following an analysis of the advice.

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to determine whether the licensee has adequately sought, managed, and, as appropriate, incorporated, advice from individuals and institutions that may be affected by the decommissioning alternative proposed by the licensee.

10 CFR 20.1403(d)(1) requires that licensees proposing to decommission a site by restricting use of the site shall seek advice from affected parties on whether:

- The provisions for institutional controls will provide reasonable assurance that the TEDE distinguishable from background radiation will not exceed 0.25 mSv/y (25 mrem/y).
- The provisions for institutional controls will be enforceable.
- The provisions for institutional controls will not impose an undue burden on the community or other affected parties.
- Sufficient financial assurance has been provided to allow an independent third party to carry out any necessary control and maintenance activities at the site after license termination.

The staff's review should verify that the following information is included in the discussion of how advice was sought, obtained, evaluated, and as appropriate, incorporated for each of the issues identified above:

- a description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee;
- a description of the manner in which the licensee obtained advice from these individuals or institutions;
- a description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice;
- a description of how the licensee provided for a comprehensive, collective discussion of the issues by the participants represented;
- a copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants;
- a description of how this summary has been made available to the public; and
- a description of how the licensee evaluated the advice, and the rationale for incorporating, or not incorporating, the advice from affected members of the community into the DP.

EVALUATION FINDINGS

Evaluation Criteria

The staff should verify that the information summarized under "Information to be Submitted," above, is included in the licensee's description of how advice was solicited, obtained, evaluated and as appropriate, incorporated into the licensee's decisions and DP. The staff should verify that the manner in which advice was sought and obtained and the activities associated with obtaining this advice are consistent with the guidance in Section 17.8 of this Volume.

17.7.2.5 Dose Modeling and ALARA Demonstration

The purpose of the review of the licensee's estimates of doses from the site after termination of the license to verify that the dose to the average member of the critical group will not exceed 0.25 mSv/y (25 mrem/y) with the institutional controls in place and that the doses are as low as reasonably achievable. The staff's review should also verify that, if institutional controls are no longer in place, there is reasonable assurance that the dose to the average member of the critical group from residual radioactive material at the site will not exceed 1.0 mSv/y (100 mrem/y), or 5.0 mSv/y (500 mrem/y) provided that the licensee:

- demonstrates that further reductions in residual radioactivity necessary to comply with the 1.0 mSv/y (100 mrem/y) requirement are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;
- makes provisions for durable institutional controls; and
- provides sufficient financial assurance to allow an independent third party to carry out rechecks at the site no less frequently than every five years and to assume and carry out responsibilities for any necessary control and maintenance of the controls at the site.

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to determine whether the residual radioactive material at the site will not result in a TEDE that exceeds 0.25 mSv/y (25 mrem/y) with institutional controls in place and is ALARA, or that if institutional controls are no longer in place that there is reasonable assurance that the TEDE to the average member of the critical group will not exceed either 1.0 mSv/y (100 mrem/y) or 5.0 mSv/y (500 mrem/y), with conditions. The information should also demonstrate that the financial assurance mechanism(s) are adequate for the site (See Section 17.7.2.3). Finally, the information should be adequate to allow the staff to determine if the institutional controls and site maintenance activities are adequate.

In conducting dose assessments, the licensee should identify realistic exposure scenarios assuming past, present, and reasonably foreseeable (i.e., a few decades and possibly up to 100 years) land uses (as described in Chapter 5 of Volume 2 of this NUREG series). Included in the assumption that the institutional controls are no longer in place, the licensee should assume that there is no maintenance and no repair of engineered barriers (if used), and as a result, should analyze how the engineered barrier might degrade over time, for example, due to erosion or biointrusion.

If a licensee proposes that a portion of its site be released for unrestricted use, then the total dose from all portions of the site must meet the applicable dose criteria. Therefore, dose assessments for both restricted and unrestricted use portions of the site are needed and also must take into consideration the impact of the other portion of the site — impacts of the restricted use portion on the unrestricted use portion (e.g., the potential for future contaminated groundwater to migrate into the unrestricted area) and impacts of the unrestricted portion on the restricted use portion.

The staff's review should verify that the following information is included in the dose modeling/ALARA demonstration subsection of the restricted use section of the DP:

- a summary of the dose to the average member of the critical group with institutional controls in place, as well as the estimated doses if they are no longer in place;

- a summary of the evaluation performed pursuant to Chapter 6 and Appendix N in Volume 2 of this NUREG series demonstrating that these doses are ALARA;
- if the estimated dose to the average member of the critical group could exceed 1.0 mSv/y (100 mrem/y), but would be less than 5.0 mSv/y (500 mrem/y):
  - a demonstration that further reductions in residual radioactivity necessary to comply with the 1.0 mSv/y (100 mrem/y) requirement are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;
  - provisions for durable institutional controls are in place; and
  - sufficient financial assurance has been provided to allow an independent third party to carry out rechecks at the site no less frequently than every 5 years and to assume and carry out responsibilities for any necessary control and maintenance of the controls at the site.

EVALUATION FINDINGS

Evaluation Criteria

The staff should verify that the information summarized under "Information to be Submitted," above, is included in the dose modeling/ALARA demonstration subsection of the restricted use section of the DP. The staff should verify that the dose to the average member of the critical group does not exceed 0.25 mSv/y (25 mrem/y) with institutional controls in place and that the licensee estimated the dose in accordance with Chapter 5 of Volume 2 of this NUREG series. The staff should verify that these doses are ALARA and that the licensee has made this evaluation in accordance with the criteria in Chapter 6 and Appendix N of Volume 2 of this NUREG series. The staff should verify that the dose to the average member of the critical group will not exceed 1.0 mSv/y (100 mrem/y), without institutional controls, and that the licensee has estimated the dose in accordance with Chapter 5 of Volume 2 of this NUREG series.

If the dose to the average member of the critical group could exceed 1.0 mSv/y (100 mrem/y), without institutional controls, the staff should verify that the dose will not exceed 5.0 mSv/y (500 mrem/y) and that the licensee has estimated the dose in accordance with Chapter 5 of Volume 2 of this NUREG series. The staff also should verify that the licensee has determined that further reductions in residual radioactivity necessary to comply with the 1.0 mSv/y (100 mrem/y) requirement are not technically achievable, would be prohibitively expensive or would result in net public or environmental harm in accordance with Chapter 6 and Appendix N of Volume 2 of this NUREG series. The staff should verify that the institutional controls provided by the licensee meet the criteria for a durable institutional controls (i.e., government ownership or responsibility as the third party). The staff should verify that the licensee has provided sufficient financial assurance to allow an independent third party to carry out rechecks at the site no less than every five years. The staff should verify that the amount of financial assurance is sufficient to assume and carry out responsibilities for any necessary control and

maintenance of the controls at the site in accordance in Part II of Volume 3 of this NUREG series.

17.7.3 ALTERNATE CRITERIA

The guidance in Section 17.7.2 for Restricted Use sites, including the risk-informed graded approach and use of new institutional control options involving NRC (i.e., LTC license and LA/RC), also apply to selecting the appropriate institutional controls for sites proposing to decommission using alternate criteria in 10 CFR 20.1404.

For certain difficult sites with unique decommissioning problems, 10 CFR 20.1404 includes a provision by which NRC may terminate a license using alternate dose criteria. NRC expects the use of alternate criteria to be limited to rare situations. This provision was included in 10 CFR 20.1404 because NRC believed that it is preferable to codify provisions for these difficult sites in the rule rather than require licensees to seek an exemption outside the rule. Under 10 CFR 20.1404, NRC may consider terminating a license under alternate criteria that are greater than 0.25 mSv/y (25 mrem/y) [but less than 1.0 mSv/y (100 mrem/y)] with restrictions in place, but NRC limits the conditions under which a licensee could apply to NRC for, or be granted use of, alternate criteria to unusual site-specific circumstances.

The purpose of the review of the licensee's discussion of why it is requesting license termination under the alternate criteria provisions of 10 CFR 20.1404 is to determine if the licensee can demonstrate that the estimated doses to the public from all man-made sources other than medical will be less than 1.0 mSv/y (100 mrem/y) and are ALARA, that appropriate restrictions are in place at the site and that the licensee has sought, obtained, evaluated and, as appropriate addressed, advice from individuals and institutions that may be affected by the decommissioning, in accordance with the criteria in 10 CFR 20.1404.

ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to determine whether the residual radioactive material at the site will result in a dose that exceeds 0.25 mSv/y (25 mrem/y), but will not exceed 1.0 mSv/y (100 mrem/y) (considering all man-made sources other than medical) and is ALARA. The information should also demonstrate that the financial assurance mechanism(s) are adequate for the site. Finally, the information should be adequate to allow the staff to determine if the institutional controls, site maintenance activities and the manner in which advice from individuals or institutions that could be affected by the decommissioning was sought, obtained, evaluated, and, as appropriate, addressed in accordance with NRC requirements. The staff should verify that the following information is included in the discussion of why the licensee is requesting license termination under the provisions of 10 CFR 20.1404:

- a summary of the dose to the average member of the critical group (considering all man-made sources other than medical);
- a summary of the evaluation performed pursuant to Chapter 6 and Appendix N of Volume 2 of this NUREG series demonstrating that these doses are ALARA;
- an analysis of all possible sources of exposure to radiation at the site and a discussion of why it is unlikely that the doses from all man-made sources, other than medical, will be more than 1.0 mSv/y (100 mrem/y);
- a description of the legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism;
- a description of any detriments associated with the maintenance of the institutional control(s);
- a description of the restrictions on present and future landowners;
-

a description of the entities enforcing and their authority to enforce the institutional control(s);

- a discussion of the durability[1] of the institutional control(s);
- a description of the activities that the party with the authority to enforce the institutional controls will undertake to enforce the institutional control(s);
- a description of the manner in which the entity with the authority to enforce the institutional control(s) will be replaced if that entity is no longer willing or able to enforce the institutional control(s);
- a description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s);
- a description of the corrective actions that will be undertaken in the event the institutional control(s) fail;
- a description of the records pertaining to the institutional controls, how and where they will be maintained, and how the public will have access to the records.
- a description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee;

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[1] The Commission has stated (see Section B.3.3 of the "Statements of Consideration" for 10 CFR Part 20, Subpart E, "Radiological Criteria for License Termination") that stringent institutional controls would be needed for sites involving large quantities of uranium and thorium contamination. Typically, these would involve legally enforceable deed restrictions and/or controls backed up by State and local government control or ownership, engineered barriers, and as appropriate, Federal ownership.

- a description of the manner in which the licensee obtained advice from affected individuals or institutions;
- a description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice;
- a description of how the licensee provided for a comprehensive, collective discussion on the issues by the participants represented;
- a copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants;
- a description of how this summary has been made available to the public; and
- a description of how the licensee evaluated advice from individuals and institutions that could be affected by the decommissioning and the manner in which the advice was addressed.

EVALUATION FINDINGS

Evaluation Criteria

The staff should determine whether the information summarized under "Information to be Submitted," above, is included in the discussion of why the licensee is requesting license termination under the provisions of 10 CFR 20.1404. The application of the criteria is dependent on the circumstances of the case. In each case the staff should consult with the Office of the General Counsel on the application of the criteria and the sufficiency of the licensee's proposal.

Review of the manner in which doses to the public should be estimated is addressed in Chapter 5 of Volume 2 of this NUREG series, and the staff should refer to Chapter 5 of Volume 2 of this NUREG series to determine if the dose estimates developed by the licensee are acceptable. The evaluation of these doses to determine if they are ALARA is addressed in Chapter 6 and Appendix N of Volume 2 of this NUREG series, and the staff should refer to Chapter 6 and Appendix N of Volume 2 of this NUREG series to review the licensee's demonstration that the doses are ALARA. The evaluation of the licensee's financial assurance mechanism(s) is addressed above and in Part II of Volume 3 of this NUREG series and the staff should refer to these sections to review the financial assurance mechanisms. The evaluation of institutional controls, site maintenance activities, and obtaining advice from individual and institutions that could be affected by the decommissioning are addressed in Sections 17.7.2.2, 17.7.2.3, and 17.7.2.4.

Changes to NUREG-1757, Vol. 1, Rev. 1, Section 17.8, "Obtaining Public Advice on Institutional Controls"

17.8 OBTAINING 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 during the decommissioning process. 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 that may be affected by the decommissioning. The rationale for this requirement 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 DP or License Termination Plan (LTP) before it is submitted to NRC for review. This section provides guidance on complying with 10 CFR 20.1403(d).

~~Once the DP or LTP is submitted to NRC, 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, 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. It is NRC's, not the licensee's, responsibility to carry out this action.~~

To comply with 10 CFR 20.1403(d) and to ensure that the fundamental performance objectives of institutional controls are met, licensees who plan to release a site under restricted conditions must satisfy the following:

- Seek advice on whether the provisions for institutional controls will:
  - — provide reasonable assurance that annual doses will not exceed 0.25 mSv/y (25 mrem/y);
  - — be enforceable; and
  - — not impose undue burden on the local community or other affected parties.
- Seek advice on whether the licensee has provided sufficient financial assurance for any necessary control and maintenance of the site by an independent third party.
- Seek advice from representatives of a broad cross-section of individuals and institutions in the community that 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 DP or LTP, how advice from the affected parties has been sought and incorporated, as appropriate, following analysis of that advice. The licensee is not required to reach consensus with the affected parties on the various aspects of the proposed institutional controls.

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

- ~~provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 0.25 mSv/y (25 mrem/y);~~
- ~~be enforceable;~~
- ~~not impose undue burden on the local community or other affected parties; and~~
- ~~be backed by sufficient financial assurance for any necessary control and maintenance of the site by an independent third party.~~

Once the DP or LTP is submitted to NRC, NRC reviews the licensee's plans for license termination, including the institutional controls proposed to restrict site use. NRC also evaluates the public comments gathered by the licensee and the licensee's consideration of comments from affected parties. As part of NRC's review process for all submitted DPs and LTPs, NRC also must notify and solicit comments from the public regarding the proposed licensee action, under 10 CFR 20.1405. Significant and appropriate public involvement in NRC's review process will take place at this time. It is NRC's, not the licensee's, responsibility to carry out these actions required under 10 CFR 20.1405.

Identifying Affected Parties

The licensee should first identify the individuals and institutions in the community who may be affected by the decommissioning (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. The affected parties may vary for each specific site and may include the following:

- any State, local, or Federal government agency, other than NRC, that has jurisdiction or responsibilities (e.g., zoning or community land use planning) 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 properties abut the site or portions of the site to be released under restricted conditions; and/or
- any Indian tribe or other indigenous people who have relevant treaty or statutory rights that may be affected by the decommissioning of the site.

Methods of 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. The type of process a licensee uses should be tailored to its site (based on site-specific considerations and the stakeholders at a site) and can include a variety of approaches. The licensee is encouraged ~~It is desirable for the licensee~~ to meet with NRC staff to discuss 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 NRC staff.

~~In obtaining input~~ Appropriate mechanisms for seeking advice from affected parties~~, licensees should convene~~ could include a public meeting or series of meetings, meetings with individual groups/organizations to discuss the licensee's decommissioning plans and obtain stakeholder input, a specific process for obtaining written or electronic public comments by e-mail or website means, or formation of a site-specific advisory board (SSAB) (i.e., a group representing a broad cross-section of the community that may be affected by the decommissioning). ~~If creation of an SSAB is not appropriate for a particular situation, the licensee may consider satisfying the requirements of 10 CFR 20.1403 by seeking advice directly from the affected parties, without the use of an SSAB.~~

Convening a SSAB

In general, NRC considers that convening a SSAB should be the starting point in providing for public involvement because a 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 the licensee develop 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 a SSAB may be considered to be a 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.

~~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 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 NRC.~~

Licensees should use the following guidance in establishing and convening a 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 DP be submitted within 12 months after notifying 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 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 DP or LTP as appropriate, and submit the DP 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 DP 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 a SSAB.
- The SSAB should:
  - select a chairperson;
  - adopt a charter and operating procedures;
  - work with the licensee to identify and obtain information needed in its evaluation process;
  - 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;
  - respond to concerns and questions raised by the public, making the results publicly available;

— provide advice to the licensee on the topics listed above and on any other topics the licensee wants discussed;

— to the extent feasible, abide by the schedule established by the licensee to meet NRC requirements; and

— 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 using print, electronic, and website notification methods. The licensee should inform NRC of SSAB meetings and distribution of information made at SSAB meetings ~~because~~, as these meetings and distributions may cause the public to contact 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.

Other Appropriate Methods for Seeking Advice

The use of a SSAB may not be appropriate in all situations, such as, 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 a licensee determines that a 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 from representatives of a broad cross-section of community interests, including governmental institutions with jurisdiction and responsibilities, that may be affected by the decommissioning (i.e., affected parties). The licensee must also conduct~~should determine ~~what are~~ the best methods to allow for a comprehensive collective discussion of the issues associated with restricted use decommissioning and an opportunity for the affected parties to provide advice on the institutional controls. ~~. The method used for interacting directly with the public and seeking such public advice should have~~ The licensee should develop a public involvement process, which has the following characteristics:

- 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,~~such as articles, advertisements, and public service announcements in newspapers, television, and radio;

  — websites or other related technologies;

  — flyers or brochures 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; or

— presentations at public meetings.

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

  The licensee should present information on the provisions for restricting uses of the site to meet the dose criteria of the LTR, the nature of the institutional controls expected to restrict use over extended time periods, how the restrictions would be enforced, the effect on the community, and the adequacy of the level of financial assurance.

- 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~~any public meeting(s). Although 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.
- 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, and could~~. There may also be a method to~~ obtain comments electronically, such as by e-mail or through a ~~W~~website. Comments received should be available for public inspection.
- The licensee should ~~hold at least three public meetings for discussion of the issues. The licensee should~~ inform NRC of any public meetings and the information distributed at the meetings, ~~because~~as these meetings and distributions may cause the public to contact 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, is to be made publicly available.

Following solicitation of advice from affected parties, the licensee will document in its DP or LTP how the advice of affected parties has been sought and incorporated, as appropriate, following analysis of that advice, but the licensee is not required to reach a consensus with the affected parties on the various aspects of the proposed institutional controls.

Suggestions for Effective Public Involvement

In relation to the information the licensee provides to the affected parties, it is important for the licensee to provide necessary background information to promote understanding of institutional controls and sufficient time to allow discussion on the institutional control issues. The licensee also could clearly identify what the permitted uses of the site are, as well as the adverse uses that must be restricted to meet the dose criteria of the LTR, as this information could assist the affected parties in providing advice on whether the proposed institutional controls impose an undue burden on them or the local community. The definition of an "undue burden" is specific to the site and its stakeholders or affected parties.

In public meetings with the affected parties, the licensee could use a facilitator to promote discussion and dialogue on the institutional control issues. The licensee also could host a roundtable discussion with a smaller group of the representatives of the broad spectrum of stakeholder interests to ensure that there is a dialogue among those key interests on the specific institutional control issues.

As the licensee develops specific plans and analyses, the discussions with the affected parties could become more detailed and could focus on topics, including the cost of maintenance and monitoring that could be needed in the future, preliminary results of dose assessments, and other special provisions, such as periodic rechecks of the restricted area and the continued effectiveness of institutional controls.

The licensee should refer to "Best Practices for Effective Public Involvement in Restricted-Use Decommissioning of NRC-Licensed Facilities" (June 2002), which was prepared for the NRC by the U.S. Institute for Environmental Conflict Resolution. This report offers guidance and advice on the best practices for achieving effective public involvement in NRC's decommissioning program, specifically for restricted use decommissioning.

Changes to NUREG-1757, Vol. 1, Rev. 1, Appendix M, "Overview of the Restricted Use and Alternate Criteria Provisions of 10 CFR Part 20, Subpart E"

M.1 INTRODUCTION

The requirements of 10 CFR 20.1403 and 10 CFR 20.1404 are briefly summarized in this overview. This overview is being included in this NUREG to provide the staff with an understanding of the philosophy and approach used by the Commission in promulgating these provisions of 10 CFR Part 20, Subpart E. Staff should refer to the appropriate sections of this guidance to evaluate licensee requests for license termination under these provisions. In addition, Sections 17.7.2.4 and 17.8 of this Volume contain guidance on seeking public advice on institutional controls which should be used to evaluate a licensee's program for compliance with 10 CFR 20.1403(d)(1–2) and 10 CFR 20.1404 (a)(4).

Prior to the promulgation of the License Termination Rule (LTR) (62 FR30958), U.S. Nuclear Regulatory Commission (NRC) regulations did not contain a provision for releasing sites for other than unrestricted use. Experience with decommissioning facilities has indicated that for certain sites, achieving the unrestricted use criterion might not be appropriate because: (1) there may be net public or environmental harm in achieving unrestricted use; (2) expected future use of the site would likely preclude unrestricted use; or (3) the cost of cleanup and waste disposal to achieve the unrestricted use criterion is excessive compared with achieving the same dose criterion by restricting the use of the site and eliminating exposure pathways.

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

NRC still considers unrestricted use to be the preferable method to decommission licensed facilities and terminate radioactive materials licenses. However, in recognition that there may be a limited number of sites where license termination with restrictions may be appropriate, the NRC included provisions for terminating the licenses for these few sites in the LTR.

M.1.1 Restricted Use

License termination under restricted conditions will be permitted pursuant to 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 [10 CFR 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 0.25 millisieverts per year (0.25 mSv/y) [25 millirem/year (25 mrem/y)] [10 CFR 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 [10 CFR 20.1403(c)].
4. The licensee has submitted a decommissioning plan or a license termination plan to the NRC that indicates the licensee's intent to release the site under restricted conditions and describes 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 [10 CFR 20.1403(d)]. In seeking this advice, the licensee would have conducted the activities for seeking advice required by 10 CFR 20.1403(d)(2), including providing for participation by a broad cross-section of community interests that may be affected by decommissioning; providing an opportunity for a comprehensive collective discussion of the institutional controls and financial assurance specified in 10 CFR 20.1403(d)(1) by the affected parties; and providing a publicly available summary of all such discussions.
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 1.0 mSv/y (100 mrem/y) or, under certain conditions, 5.0 mSv/y (500 mrem/y). If the 5.0 mSv/y (500 mrem/y) value is used, the licensee must: (1) demonstrate that achieving 1.0 mSv/y (100 mrem/y) is prohibitively expensive, not technically achievable, or would result in net public or environmental 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 and maintenance at least every 5 years and carry out any necessary controls and maintenance [10 CFR 20.1403(e)].

The NRC staff will review and evaluate the decommissioning plan and will solicit public input to determine whether the above requirements are satisfied, pursuant to 10 CFR 20.1405. 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, 10 CFR 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. Please note that the Commission has explicitly chosen not to define what constitutes "new information" or "significant public risk," because this determination will be made on a case-by-case basis. ~~Also note that there is some potential that a license termination could be revisited as a result of a future Environmental Protection Agency (EPA) rulemaking.~~

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. Additionally, a

licensee that had planned unrestricted release may find during remediation that unrestricted release is not practical. In these instances, the licensee should submit an amended decommissioning plan or license termination plan to NRC as soon as possible.

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.

M.1.2. Alternate Criteria

Under 10 CFR 20.1404, the NRC may consider terminating a license using alternate criteria that are greater than 0.25 mSv/y (25 mrem/y), with restrictions in place. However, licensees requesting license termination under the alternate criteria provisions of 10 CFR 20.1404 would still need to ensure that potential doses from residual radioactivity are less than 1.0 mSv/y (100 mrem/y) with restrictions in place. In addition, the NRC will limit the conditions under which a licensee could apply to the NRC for, or be granted use of, alternate criteria to unusual site-specific circumstances subject to the following provisions:

1. 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 1.0 mSv/y (100 mrem/y). A licensee proposing to use alternate criteria would have to provide a complete and comprehensive analysis of such possible sources of exposure.
2. The licensee has employed, 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.
3. The licensee has reduced doses to ALARA levels, based on a comprehensive analysis of risks and benefits of all viable alternatives.
4. The licensee has sought advice from affected parties regarding the use of alternate criteria at the site. In seeking this advice, the licensee would have conducted 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 that may be affected by decommissioning; providing an opportunity for a comprehensive collective discussion of the issues related to the alternate criteria by the affected parties; and providing a publicly available summary of all such

discussions.[2] As part of this process, the licensee would submit a decommissioning plan indicating how advice of individuals and institutions in the community that may be affected by the decommissioning has been sought and addressed.

5. The licensee has obtained the specific approval of the Commission for the use of alternate criteria. The Commission will make its decision after considering the NRC staff's recommendations that would address any comments provided by the EPA and any public comments submitted regarding the decommissioning plan pursuant to 10 CFR 20.1405.

M.1.3. Institutional Controls

Institutional controls are used to limit intruder access to, and/or use of, the site to ensure that the exposure from the residual radioactivity does not exceed the established criteria. Institutional controls include administrative mechanisms (e.g., land use restrictions) and may include, but not be limited to, physical controls (e.g., signs, markers, landscaping, and fences) to control access to the site and minimize disturbances to engineered barriers. There must be sufficient financial assurance to ensure adequate control and maintenance of the site. As discussed below, they must be legally enforceable and the entity charged with their enforcement must have the capability, authority, and willingness to enforce the institutional controls. If the institutional control includes physical controls, they must include measures to monitor their performance and to provide for their maintenance or replacement along with sufficient financial assurance to provide for the necessary monitoring, maintenance or replacement.

Institutional controls address a variety of restrictions and need to be tailored to each site situation. Restrictions may include prohibitions on farming, industrial, recreational, or residential use. Prohibitions on excavation and water use may also be warranted. Institutional controls are usually characterized as "proprietary" or "governmental." Generally, a layering of different restrictions and mechanisms are needed to provide for durable and effective institutional controls.

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

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[2] Licensees are required by 10 CFR 20.1403 to obtain advice from institutions and individuals that may be affected by the decommissioning on specific issues related to institutional controls and financial assurance. However, 10 CFR 20.1404 provides for a much broader discussion of the issues associated with the use of alternate criteria, and, as such, licensees must obtain advice on essentially any issue associated with the use of alternate criteria.

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 as "governmental institutional controls." Among the more common governmental institutional controls are zoning, well-use restrictions, and building permit requirements.

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.

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.

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.

In addition to requiring that the institutional controls function to limit the dose to 0.25 mSv/y (25 mrem/y) 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 need to meet the following criteria:

1. If the annual dose to the average member of the critical group would not exceed 1.0 mSv/y (100 mrem/y) if the institutional controls were no longer in effect, a private individual, organization, or Federal, State or local government may be acceptable as the entity responsible for enforcing the institutional control[3] depending on the circumstances at the site; or

[3] The Commission has stated (see Section B.3.3 of the "Statements of Consideration" for 10 CFR Part 20, Subpart E, "Radiological Criteria for License Termination") that stringent institutional controls would be needed for sites involving large quantities of uranium and thorium contamination. Typically, these would involve legally enforceable deed restrictions and/or controls backed up by State and local government control or ownership, engineered barriers, and as appropriate, Federal ownership.

2. If the annual dose could exceed 1.0 mSv/y (100 mrem/y) but be less than 5.0 mSv/y (500 mrem/y), 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. On privately owned land, a Federal, State or local government as the entity responsible for enforcing the restriction could also be acceptable, depending on the circumstances at the site.

Finally, restrictions will need to remain in place for the duration that they are needed, up to 1000 years. 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 0.25 mSv/y (25 mrem/y) 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 NRC staff will review and evaluate the decommissioning plan and will solicit public input to determine whether the above requirements are satisfied, pursuant to 10 CFR 20.1405.

M.1.4 Institutional Control Implementation Issues

NRC and licensees have had difficulty implementing the LTR requirements for license termination under restricted conditions. For example, States have not been agreeable to becoming the independent third party to act as a backup to an owner and often oppose the restricted use approach. Similarly, NRC's efforts to make arrangements for DOE to take ownership of commercial sites and provide the necessary access and land use controls or maintenance under the provisions of Section 151(b) of the Nuclear Waste Policy Act of 1982 have not been successful. Finally, for sites with long half-life radionuclides such as uranium and thorium, long-term effectiveness of institutional controls is recognized as a significant challenge given many examples of institutional control failure even after short periods of time.

In response to these difficulties that caused decommissioning delays, NRC evaluated the institutional control issues and developed new policies that should help resolve the issues. These evaluations and new policies are described in the LTR Analysis (SECY-03-0069), and a May 2004 Regulatory Issue Summary, RIS-2004-08. These new policies are described below.

M.2 RISK-INFORMED GRADED APPROACH TO INSTITUTIONAL CONTROLS

The first of the three new policies is a risk-informed graded approach to selecting institutional controls under the LTR, so that licensees can have flexibility to arrange the appropriate level of controls. The risk-informed graded approach consists of risk framework and associated grades of

institutional controls. The general risk framework is defined by the hazard level and likelihood of hazard occurrence. The hazard level is established in the LTR (10 CFR 20.1403(e)(ii)) as the dose level of 1.0 mSv/y (100 mrem/y), calculated assuming institutional controls are not in effect. This dose level is the public dose limit. Sites with calculated doses above the public dose limit, but below 5.0 mSv/y (500 mrem/y), are considered higher risk sites. Those sites below the public dose limit are considered lower risk sites. In addition, higher risk sites are those with longer hazard duration (e.g., longer dose persistence or longer half-life, greater than 100 years). The LTR also defines the general grades of controls: sites below the 1.0 mSv/y (100 mrem/y) dose level require legally enforceable institutional controls, and sites above the 1.0 mSv/y (100 mrem/y) dose level require both legally enforceable and durable institutional controls. Thus, the LTR requires that institutional controls provide more reliable or sustainable protection over the time period needed (i.e., durable) for higher risk sites that could exceed the public dose limit assuming no restrictions. Durable institutional controls are also appropriate for long-lived radionuclides regardless of the dose limit. Therefore, the hazard magnitude and duration criteria for a higher risk site define when durable institutional controls are needed. Table M.1 illustrates this risk-informed graded approach and gives examples.

Specific grading of institutional controls can be selected within the two general grades defined above. This approach recognizes that the site-specific factors affecting risk can be highly variable from site to site. As a result, specific grading recognizes the need for flexibility to tailor institutional controls to achieve the desired effectiveness. Specific grading involves evaluating and balancing numerous site-specific factors such as: (a) physical characteristics of the site that limit future land use; (b) land uses that could be adverse to performance/compliance and therefore should be prohibited; (c) land uses that are acceptable and could result in productive reuse of the site; (d) dose assessment results; e) engineered barriers and related maintenance; (f) monitoring controls and maintenance; (g) jurisdictional limitations on enforceability and long-term effectiveness of institutional controls; and h) advice from affected parties, such as local governments and the public.

The graded approach has important benefits. For the public, protection is increased, especially over the long term. The approach clearly identifies when durable controls might be needed and specific controls would be designed to mitigate site-specific risks that are significant to maintaining safety. For licensees and NRC, clearer guidance is provided for licensees to select institutional controls and NRC to review licensees' proposed controls. Licensees also have the flexibility to select appropriate controls that could be less costly and easier to arrange.

Table M.1 NRC'S Risk-Informed Graded Approach for Institutional Controls to Restrict Site Use

Lower Risk **Lower Hazard Level [0.25–1.0 mSv/y (25–100 mrem/y)]** **Shorter Hazard Duration – Lower Likelihood of IC Failure** **Shorter Dose Persistence or Half-Life (less than 100 years)**	**Higher Risk** **Higher Hazard Level [1.0–5.0 mSv/y (100–500 mrem/y)]** **Longer Hazard Duration – Higher Likelihood of IC Failure** **Longer Dose Persistence or Half-Life (greater than 100 years) ***
General Grade Legally enforceable institutional controls Specific Grade Tailor specific type of institutional controls and land use restrictions to site-specific circumstances using scenario analyses from dose assessments Examples Single conventional "deed restriction," such as a restrictive covenant (less control) Layered/redundant controls such as restrictive covenant, deed notice, and State registry (more control) (Note that either the NRC Long-Term Control license or legal agreement/restrictive covenant could be used if other types of conventional institutional controls cannot be established.)	General Grade Durable and legally enforceable institutional controls with 5-year review Specific Grade Tailor specific type of institutional controls and land use restrictions to site-specific circumstances using scenario analyses from dose assessments Examples Layered/redundant controls that include State government control (durable) Conventional institutional control with NRC monitoring and enforcement after license termination using legal agreement and restrictive covenant (durable) Conventional institutional control with NRC monitoring and enforcement after license termination using regulatory authority under 10 CFR 20.1401(c) (more durable) State or Federal government ownership and control (NWPA §151(b)) (most durable) NRC Long-Term Control license (most durable)

* It may be appropriate to treat sites with longer half-life radionuclide contamination, but with doses close to 0.25 mSv/y (25 mrem/y) assuming no controls, as "Lower Risk" sites.

M.3 LONG-TERM CONTROL LICENSE OPTION

NRC staff recommended to the Commission, in SECY-03-0069, that a new type of possession-only specific license for long-term control be established as one option for resolving the LTR institutional control issue at sites where restricted use or alternate criteria could be used. This new type of possession-only license is referred to in this guidance as a long-term control (LTC) license to clearly distinguish it from the NRC's existing possession-only licenses for storage. The existing possession-only license is typically used at NRC licensed sites in the operating or decommissioning phases. In contrast, the LTC license is for use as an institutional control in the long-term control phase after completion of decommissioning. Attachment 1 of SECY-03-0069 provides a description and evaluation of the staff's recommended option of possession-only license for long-term control. On November 17, 2003, the Commission approved this LTR recommendation (SRM-SECY-03-0069).

M.3.1 Purpose of LTC License

The primary purpose of NRC's LTC license is to provide the legally enforceable and durable institutional controls required by 10 CFR 20.1403(b) to ensure the long-term protection of the public health, safety, and the environment. Therefore, the LTC license is for long-term control of a restricted use site after decommissioning is completed.

The conditions of the LTC license would specify the necessary controls to limit site access and land use that the licensee must monitor and maintain and that NRC would inspect and enforce, if necessary. The LTC license also would specify other required long-term control activities to be conducted by the licensee, such as surveillance, maintenance, reporting, records retention, and stakeholder involvement (see guidance below). Detailed plans to implement the LTC license conditions would be given in a Long-Term Control and Maintenance Plan that the licensee would prepare and NRC would approve during decommissioning and before the LTC license is established.

M.3.2 Roles and Responsibilities

The licensee has the primary responsibility for long-term protection of the public health, safety, and the environment by implementing and then maintaining the effectiveness of the controls required by the LTC license. The licensee would maintain the required site access and land use controls, as well as engineered barriers, using periodic surveillance, maintenance, and monitoring, if needed. The licensee also would provide an annual report to NRC, with copies to State and local governments. Finally, licensing records would be maintained by the licensee.

NRC is responsible for assuring that the licensee's controls and maintenance remain effective by conducting oversight reviews, making periodic inspections, conducting five-year license renewals, issuing a new LTC license when ownership changes in the future, enforcing the license, if needed, and maintaining licensing records for the duration of the LTC license.

Oversight reviews could include reviewing licensee annual reports and other reports (e.g., corrective action reports or requests for NRC approval of the sale of the site) and obtaining advice from stakeholders. NRC's inspection role might include an annual inspection for the first five years and then once every five years thereafter as part of the license renewal process. Periodic inspections might also be needed to address specific adverse events, allegations, and licensee corrective actions. NRC inspections could involve seeking advice and information from stakeholders. A license renewal process also would be conducted every five years, considering licensee reports, NRC inspections, and stakeholder advice. License renewal is a regulatory mechanism to evaluate the sustainability of the LTC license over the long term including: effectiveness of site access and land use controls, licensee performance, new site information, and sufficiency of funding. These evaluations could result in revised license conditions necessary to ensure long-term effectiveness of controls. Enforcement actions may be taken if the conditions of the license are not met.

Stakeholders have a role under the LTR during the licensee's preparation of the decommissioning plan for a restricted use site. For these sites, the licensee is required by 10 CFR 20.1403(d) to seek advice from affected parties regarding a number of matters, including the plans for enforceable institutional controls, sufficient financial assurance, and undue burdens on the local community or other affected parties. The licensee shall document in the decommissioning plan how the advice was sought and incorporated, as appropriate, following analysis of that advice. Similarly, under 10 CFR 20.1405, NRC shall notify and solicit comments from the public upon receipt of the decommissioning plan.

In addition to the State and EPA, other stakeholders may have an ongoing interest in the site after decommissioning has been completed and the LTC license is in place. From time to time, it might be appropriate to schedule public meetings, such as during the five-year license renewal process, to obtain information about the site and to maintain a local awareness of the site and the restrictions on site access and use.

M.3.3 Requirements for Licensees Proposing Restricted Use with the LTC License

The decommissioning goal for a site proposing the LTC license is the same as any other decommissioning site proposing restricted use — safe site decommissioning that complies with the LTR. However, for such sites, the license is not terminated after remediation; it is amended to become an LTC license. Nevertheless, a licensee proposing to use the LTC license needs to comply with all the criteria of 10 CFR 20.1403, even though the license will not be terminated. These restricted use requirements for licensees are:

- 10 CFR 20.1403(a): Eligibility for restricted use (ALARA or public/environmental harm)
- 10 CFR 20.1403(b): Legally enforceable institutional controls and 0.25 mSv/y (25 mrem/y) dose criterion. (The institutional control requirements would be met with the LTC license conditions.)

- 10 CFR 20.1403(c): Sufficient financial assurance for control and maintenance
- 10 CFR 20.1403(d): A decommissioning plan or a license termination plan for restricted use that includes how advice from affected parties has been sought and incorporated
- 10 CFR 20.1403(e): 1.0 mSv/y (100 mrem/y) and 5.0 mSv/y (500 mrem/y) dose "cap" requirements if institutional controls were no longer in effect

In addition, because the NRC license would be amended and not terminated, other NRC requirements for NRC licensees would continue, such as recordkeeping.

M.3.4 Eligibility for Restricted Release and the LTC License Option

In the Statements of Consideration for the LTR, the Commission noted that it allows restricted use as an appropriate method of decommissioning while maintaining the philosophy that "…in general, termination of a license for unrestricted use is preferable because it requires no additional precautions or limitations on use of the site after licensing control ceases, in particular for those sites with long-lived nuclides."

As a result, sites considering restricted use must first comply with the existing "eligibility" requirements of 10 CFR 20.1403(a) that further reductions in residual radioactivity to comply with unrestricted use criteria would result in net public or environmental harm or are not being made because the levels associated with restrictions are as low as reasonably achievable (ALARA).

In addition, the use of the LTC license option would be an acceptable option if:

a. Durable institutional controls are required because the site is considered higher risk under the staff's graded approach to institutional controls in Table M.1.
b. The licensee can demonstrate to NRC satisfaction that it was unable to establish other types of acceptable institutional controls and independent third party arrangements (e.g., letter from the State rejecting responsibility for ownership, control, or independent third party oversight).
c. The site would need long-term monitoring or maintenance requiring technical skills to conduct.

M.3.5 Partial Restricted Release under an LTC License and Maintaining Single Ownership of the Site

Under the LTC license option, there is flexibility in the approach to subdivide the existing site and allow license termination or release of unrestricted use portions of the site while maintaining the restricted use portion(s) under the LTC license.

For government owned sites, the site could be subdivided and unrestricted use portions could be released from the license for reuse. The remaining restricted use portion(s) would remain under the license and sustained government ownership would be assumed.

Similarly, for private sites, where the restricted use portion would clearly have resale value to sustain future ownership (even with restrictions on use), the site could be subdivided and unrestricted use portions could be released for reuse. For example, if the restricted use portion has soil contamination or buried contaminated slag but an industrial use would be safe (e.g., warehouse or parking lot), then it would likely have a resale value. For this case, sustaining ownership would be more likely because of the value of the property and the potential for an "abandoned" site in the future would be reduced.

A different approach would be needed for privately owned sites where long-term controls are needed and where the restricted use portion has little or no resale value, but the unrestricted use portion has valuable reuse that would sustain future ownership, both at the present time and in the future. For this case, the preferred approach would be to maintain the current license boundaries, including both the restricted and unrestricted use portions together. Even under the LTC license, the unrestricted use portion would be available for any use consistent with local zoning constraints. The only restriction on these portions of the site would be to: (1) conduct monitoring, if needed, and (2) prohibit the sale separately from the restricted use portion containing the residual contamination. The staff recognizes that this approach is a challenging issue with pros and cons. Some pros and cons are given below.

- Pros:
  - The unrestricted use portion of the site could have resale value that balances the lack of resale value or even perception of liability associated with the restricted use portion. Prospective buyers would clearly understand the permitted uses on the unrestricted use portion. Permitted uses should enhance future resale of the site (with both restricted and unrestricted use portions) as a whole. Overall, this approach would help ensure sustainability of owner/licensee controls, and thus protection of public health and safety, for sites that need long-term control and where numerous ownership changes are expected over the long-term. This approach minimizes the possibility of the restricted portion of the site being abandoned in the future, if there is a gap in ownership.
  - This approach is intended to allow reuse of the site while enhancing the long-term protection.
  - Maintaining ownership is the most effective and efficient approach to long-term protection. While NRC would have some options in the event of a gap in ownership, these options could be difficult and time consuming to establish.
  - Maintaining ownership of the complete site would help ensure monitoring over the long-term, if needed.

- Cons:
  - Under this approach, the sensitivity to an NRC license might discourage future reuse of the unrestricted portion of the site and impact productive future use and revenue for the local community.

    It is important to note that the licensee must provide for sufficient financial assurance (an independent trust fund) to allow a third party to monitor and maintain the site for the long-term; therefore, future entities would not be responsible for any costs associated with the monitoring or maintenance or routine costs. This approach would eliminate the liability of future owners, as long as they abided by the provisions of the LTC license. Clearly communicating this in the LTC license could help reduce this sensitivity.

  - There could be a perception that this approach is inconsistent with NRC's existing policy for partial site release for operating sites, for example a power reactor that could maintain an independent spent fuel storage installation (ISFSI) on a portion of the original site and release the remaining portion for unrestricted use.

    While the two approaches might seem inconsistent, they have different purposes and time periods, and therefore are not the same. The partial site release example for an ISFSI is for the purpose of short-term storage of up to a few decades, and therefore maintaining ownership should not be a concern. In contrast, the purpose of the LTC license approach for a restricted use site needing restrictions for a long time period is to sustain ownership and a license over a long time period where ownership is expected to change many times.

  - This approach could be legally challenged.

M.3.6 Minimizing the Size of the Restricted Area

The licensee should minimize the size of the restricted portion of the site, while also considering dose assessments and the need for monitoring in its determination of what area needs to be restricted. Such an approach would contribute to demonstrating ALARA. It also would result in a smaller area to control, which may make access limitations like fencing and surveillance simpler and more effective.

M.3.7 Flexibility to Seek Unrestricted Release in the Future

The LTC license is not necessarily permanent, but would be in place as long as needed to protect public health and safety and the environment based the half-life of the radionuclides and other factors. Similarly, the LTC license would not preclude a licensee from removing residual radioactivity in the future and seeking unrestricted release. For this case, a licensee would submit a decommissioning plan for NRC review and then conduct the approved remediation and final status survey as is currently required. For example, at a site with contaminated slag, if reuse of the slag becomes viable, the licensee could submit a license amendment request and

decommissioning plan for NRC approval. After NRC approval of the DP and license amendment for decommissioning, the material could be removed for reuse and the LTC license terminated with unrestricted use. Thus, unrestricted use would not be precluded by the LTC license.

M.3.8 Transfer of control/ownership and deed notice

Transfers of site ownership are expected over the long-term, and the new owner(s) will need to become the licensee and provide the controls as specified in the conditions of the LTC license. Thus, the required control and maintenance under the LTC license would continue to be effective over the long-term even when ownership transfers as a condition of the license. The licensee must notify NRC of a potential sale and obtain NRC approval of the new owner by amending the license prior to the effective date of the sale of the licensed property. The licensee and potential new owner would submit to NRC a request for ownership transfer that would include information about the new owner such as: financial viability; willingness to accept their new responsibilities under the LTC license; technical capability to conduct monitoring, maintenance, and potential corrective actions; and willingness to become an NRC licensee. The prospective owner must become an NRC licensee effective at the time of the sale. The licensee also must establish and maintain/re-record a deed notice, approved by NRC, as a condition of the license. This will provide additional assurance that potential future owners will be informed that an NRC LTC license is required as well as the conditions of the license.

M.3.9 Sufficient Financial Assurance and Trust

The licensee must establish a trust and place sufficient funds into it to produce annual income that is sufficient to cover the (1) annual average costs of licensee surveillance, control, radiological monitoring of surface and groundwater if needed, and routine maintenance, (2) NRC oversight costs, and (3) trustee fees and expenses. The licensee should assume 1 % return on investment (consistent with 10 CFR Part 40, Appendix A). This trust fund is independent of the licensee and, therefore, not affected in the event of licensee bankruptcy and would continue independent of site ownership. The NRC would be the beneficiary of the trust. The licensee would request, and the independent trustee would pay, in accordance with the instrument, for the costs of surveillance, control, maintenance, and NRC oversight costs, most likely on an annual basis. Because the fund would produce income sufficient to hire a contractor to perform the surveillance and control tasks, the licensee could hire a contractor to perform the duties, and be reimbursed for the full cost, rather than performing the work itself.

In the event the licensee does not perform its duties, or goes bankrupt, NRC could take enforcement action, as necessary, to ensure that control activities are maintained. Alternatively, the trustee could be directed by NRC to provide funds to a contractor to work on behalf of the licensee. NRC could seek a court to appoint a custodial trustee to continue the long-term control activities using funds from the trust in the event that no licensee exists.

M.3.10 NRC Fees for LTC Oversight Activities

No annual fees (10 CFR Part 171) are required for the LTC license. However, fees for NRC services would be recovered (10 CFR Part 170). Therefore, the licensee would be charged for NRC activities during the year, expected to be review of one annual report, annual inspections during the first five years, license renewal activities every five years, enforcement actions if needed, and responses to events and licensee corrective actions as needed. The licensee should assume an NRC fee of $10,000 for one report review and one inspection each year. Also assume a fee of $20,000 once every five years for the five-year license renewal, expanded inspection, and report review. These fees are in 2005 dollars and should be adjusted for inflation. To adjust for inflation, use the ratio of the cost of professional staff hours found in 10 CFR 170.20. In 2005, the staff-hour cost for NMSS was $197 per hour.

M.3.11 Finality of Decommissioning Decisions

NRC recognizes the importance of the finality of its decommissioning decisions. Under 10 CFR 20.1401(c), the Commission could require additional cleanup in the future, based on new information, if it determines that the criteria in the LTR were not met and residual radioactivity remaining at the site could result in significant threat to public health and safety. This requirement also would apply to a site with the LTC license and may be particularly important to potential future owners/licensees who may be concerned about future liabilities should they purchase the site.

M.3.12 Long-Term Record Retention and Availability

The licensee will be required to maintain the decommissioning records that are necessary for maintaining effective long-term protection. In addition, new LTC records must be maintained for the duration of the LTC license. The purpose of recordkeeping is to support those LTC licensee activities necessary for effective long-term protection. In the event of ownership and license transfer in the future, there are existing NRC requirements for records transfer to ensure that important records remain available.

In addition, NRC intends to continue maintaining the LTC licensing records in the same docket file used for operations and decommissioning. This approach should result in a continuous and completely documented history of the site operations, decommissioning, and long-term control available in a single file that will improve the efficiency and effectiveness of future search and retrieval of site information. These records are expected to be available to the public in the future. Finally, NRC currently maintains the site decommissioning database, which includes restricted use sites. This publicly available database provides web-based access to general site information about all NRC decommissioned sites.

NRC recognizes that maintaining records and making them publicly available over the long term is one of the important elements to ensure protection for long periods of time so that knowledge of the site will not be forgotten. Retention of duplicate records in different locations by the licensee and NRC enhances long-term record retention.

M.3.13 Content of the LTC Possession-Only License and LTC Plan

LTC license conditions specify requirements for: prohibited site access and land use, permitted site access and land use, physical controls (fences, signs, monuments), surveillance, groundwater monitoring (if needed), corrective actions, maintenance, reporting, records retention and availability.

The LTC Plan provides site information and implementation activities and procedures for each license condition (similar to the Long-Term Surveillance Plan for uranium mill tailings sites required by 10 CFR Part 40, Appendix A. See Appendix D of NUREG-1620, Rev. 1 for guidance). The LTC Plan would include the following information:

- Legal description and ownership of the land
- Final condition of the site, residual contamination, engineered barriers, and physical controls
- LTC license conditions and implementing activities and procedures (e.g., restrictions on land use, monitoring requirements, and reporting requirements)

M.4 LEGAL AGREEMENT AND RESTRICTIVE COVENANT (LA/RC)

M.4.1 Purpose of LA/RC

The primary purpose of NRC's legal agreement and restrictive covenant (LA/RC) option is to provide the legally enforceable and durable institutional controls required by 10 CFR 20.1403(b) to ensure the long-term protection of the public health, safety, and the environment. The combination of a legal agreement and restrictive covenant is an institutional control option with the NRC having an enforcing role after license termination under restricted conditions.

The current licensee or site owner and NRC enter into a legal agreement on the restrictions and controls needed for restricted use. The legal agreement includes using a restrictive covenant, which outlines the restrictions on site use and any necessary maintenance, monitoring, or reporting. Monitoring could include the owner agreeing to provide a response annually or at other frequency to an NRC inquiry on effectiveness of controls or land uses.

In the legal agreement, the licensee or site owner agrees to abide by the restrictive covenant, to record the restrictive covenant in the deed, and to not withdraw the restrictive covenant from the deed. In the legal agreement, NRC agrees to monitor and enforce the restrictions, under the authority written into the legal agreement and restrictive covenant. The legal agreement is only

between the NRC and the present owner (owner at time of license termination or completion of decommissioning) and includes language that requires the present owner to record the restrictive covenant with the proper recordation body (e.g., Registrar of Deeds) and to not modify or rescind the restrictive covenant. This will help assure that the restrictive covenant will run with the property and will be binding upon all subsequent owners. NRC would need to approve any modifications to or recision of the restrictive covenant. The legal agreement and restrictive covenant should also contain a legal description of the property, and if there are both unrestricted and restricted portions, a clear delineation of these portions of the site.

Under the LA/RC option, after the licensee demonstrates compliance with all of the requirements for restricted use under the LTR, the license is terminated, and the legal agreement and restrictive covenant become the legal tools for maintaining needed restrictions on the site.

The LA/RC option provides flexibility for a formerly licensed site where the current owner does not want to become a licensee or for current licensees where the owner may want license termination. However, as the LA/RC option has not been implemented by the NRC or legally tested, the LTC license option is the preferred option for institutional controls (with NRC long-term oversight), as NRC licensing and enforcement is a proven approach. In addition, if complex monitoring or maintenance of a site is needed, where the site owner needs to have knowledge or expertise to carry out these activities, the LA/RC option should not be used. In this case, it is more appropriate to use the LTC license, as NRC would need to review and approve any transfer of the site to a new owner, as the new owner would need to become an NRC licensee. Section 17.7.2.2.1 further discusses the criteria for determining whether the LA/RC or the LTC license option should be used.

M.4.2 Enforceability of the LA/RC

It is the licensee's responsibility to demonstrate that the LA/RC option is a legally enforceable institutional control, given that the enforceability of this option depends on the property laws in the jurisdiction where the site is located. The licensee should obtain an independent legal opinion or analysis of the property laws in the jurisdiction where the site is located, demonstrating that the restrictive covenant would transfer to each subsequent owner of the property through the deed and "run with the land." The independent legal opinion should address the following issues:

- how future owners or operators of the property will have notice of the restrictive covenant;
- whether the restriction on land use can pass to the next owner when the property is sold;
- whether the restrictive covenant can be enforced by governmental entities or agencies (NRC, as well as local and State governments, who may be enforcing parties), which do not own any property in close proximity to the restricted property;
- whether the restrictive covenant/deed restriction is enforceable in perpetuity, or whether it would become unenforceable after the elapse of some period of time by operation of law;

- if the property is rezoned for a use which is restricted per the restrictive covenant, whether such rezoning would void or nullify the restrictive covenant; and
- if there are restricted and unrestricted portions of the property, whether the restrictive covenant would continue with the new deed/title of the restricted portion of the property, if, in the future, the property is divided.

Under the LA/RC option for institutional controls, NRC would enforce the restrictions under authority written into the legal agreement and restrictive covenant. If there was a breach of the legal agreement or restrictive covenant, NRC would address this by taking legal action in a court of the appropriate jurisdiction. NRC also could exercise its authority under the Atomic Energy Act, as amended, and take appropriate actions to assure that the use of the site or site conditions are protective of public health and safety.

The legal agreement and restrictive covenant would outline the methods and frequency in which NRC (as the enforcing party) would verify that the site owners were complying with the restrictive covenant. For example, NRC may correspond with the site owner annually, inquiring as to how the site is being used, or may conduct an inspection at the site at least every five years to verify that restrictions remain in place and that the site is being used appropriately. NRC also could review the property laws in the jurisdiction where the site is located at the time site ownership changes (or at least every five years), to assure that the laws still support the enforceability of the restrictive covenant. The LA/RC would outline how the NRC would enforce the restrictions, and if the legal agreement or restrictive covenant was breached, what steps NRC would take to restore the restrictive covenant (and the land use restrictions, monitoring, or reporting actions it contains). For example, if NRC determined that the site was being used inappropriately, it could take legal action in the courts to order the owner to restore the site to proper use.

M.4.3 Roles and Responsibilities

The site owner has the primary responsibility for long-term protection of the public health, safety, and the environment by implementing and then maintaining the effectiveness of the controls required by the restrictive covenant. The site owner would maintain the required site access and land use controls and would conduct any necessary maintenance and monitoring. The site owner would also maintain any necessary records related to complying with the restrictive covenant and for any monitoring and maintenance needed.

NRC is responsible for assuring that the controls and restrictions on the site continue and that the use of the property is consistent with the restrictive covenant. NRC should periodically verify the effectiveness of controls, by sending inquiries to the site owner and conducting periodic inspections. NRC is responsible for taking actions to enforce the legal agreement and restrictive covenant, if the conditions of these legal instruments are not met. NRC also is responsible for maintaining the records associated with the restricted use of the site.

Stakeholders also have a role under the LTR during the licensee's preparation of the decommissioning plan for a restricted use site. For these sites, the licensee is required by 10 CFR 20.1403(d) to seek advice from affected parties regarding a number of matters, including the plans for enforceable institutional controls, sufficient financial assurance, and undue burdens on the local community or other affected parties. The licensee shall document in the decommissioning plan how the advice was sought and incorporated, as appropriate, following analysis of that advice. Section 17.8 of this Volume discusses obtaining public advice on institutional controls in more detail. Similarly, under 10 CFR 20.1405, NRC shall notify and solicit comments from the public upon receipt of the decommissioning plan.

In addition to local and State governments and the EPA, other stakeholders may have an ongoing interest in the site after decommissioning has been completed and the restrictive covenant is in place. From time to time, it might be appropriate to schedule public meetings or solicit input from the local community or affected parties about the site, to maintain a local awareness of the site and knowledge of the restrictions on site access and use.

M.4.4 Transfer of Control/Ownership

The LA/RC option should only be used at sites where there are no monitoring or maintenance activities that would require the site owner to have special expertise or knowledge to carry them out. Therefore, it would not be necessary for NRC to approve the transfer of site ownership, as the property is sold. Instead, NRC would continue to monitor the site, to ensure that the restrictive covenant was still in effect and that the site owner was abiding by the provisions of the restrictive covenant. A provision could be included in the LA/RC, which provides that the site owner must notify NRC when it is planning to sell the property. NRC, at that time, may wish to review the property laws in the jurisdiction where the site is located to make sure that the laws continue to support the enforceability of the restrictive covenant by NRC. As previously noted, NRC also may also periodically review (e.g., every five years) the property laws in the jurisdiction where the site is located, to assure that the laws still support the enforceability of the restrictive covenant.

M.4.5 Sufficient Financial Assurance and Trust

As required in 10 CFR 20.1403(c), the licensee or site owner must establish sufficient financial assurance for the long-term cost of any necessary monitoring, maintenance and control of the site, and the cost of NRC monitoring and enforcing the controls (as the independent third party). The licensee, as part of the license termination and the establishment of the legal agreement and restrictive covenant, should provide a single payment (in an independent fund) for future maintenance and monitoring costs.

At the time of establishing the LA/RC, the licensee must establish a trust and place sufficient funds into it to produce annual income that is sufficient to cover the (1) annual average costs of any surveillance, control, monitoring or routine maintenance, (2) NRC oversight costs, and

(3) trustee fees and expenses. The licensee should assume a 1% return on investment (consistent with 10 CFR Part 40, Appendix A). This trust fund is independent of the licensee or site owner and, therefore, not affected in the event of site owner bankruptcy and would continue independent of site ownership. The NRC would be the beneficiary of the trust. The site owner would request, and the independent trustee would pay, in accordance with the instrument, for the costs of surveillance, control, maintenance, and NRC oversight costs, most likely on an annual basis. Because the fund would produce income sufficient to hire a contractor to perform the surveillance and control tasks, the site owner could hire a contractor to perform the duties and be reimbursed for the full cost, rather than performing the work itself.

M.4.6 Finality of Decommissioning Decisions

NRC recognizes the importance of the finality of its decommissioning decisions. Under 10 CFR 20.1401(c), the Commission could require additional cleanup in the future, based on new information, if it determines that the criteria in the LTR were not met and residual activity remaining at the site could result in significant threat to public health and safety. This requirement also would apply to a site with a restrictive covenant and may be particularly important to potential future owners/licensees who may be concerned about future liabilities should they purchase the site.

It is also important to note that if a future site owner wished to decommission the property to unrestricted use, it would be able to propose this to NRC. The LA/RC option for restricted use does not preclude a future decommissioning to meet the radiological criteria for unrestricted use. In that case, the site owner would submit a decommissioning plan for NRC review and decommission the site in accordance with NRC's decommissioning regulations, and the NRC would assure that the site is properly decommissioned and suitable for unrestricted use, before taking actions to terminate or rescind the restrictive covenant (remove it from the deed).

M.4.7 Long-Term Record Retention and Availability

There is concern that over time, knowledge of the site conditions and appropriate uses of the site may be lost. NRC recognizes that maintaining records and making them publicly available over the long term will help to preserve public knowledge of the site and the restrictions on its use. Preserving this knowledge and ensuring that pertinent information related to the site is easy to find and is readily accessible, is one of the important elements to ensure protection of public health and safety for long periods of time. One approach to managing this information is to duplicate the responsibilities of different agencies and groups for retaining records, as well as maintain the records in different locations, to better assure that the records will be preserved and made available to those who use the site in the future.

Under the LA/RC option, NRC would have the primary responsibility for maintaining records and making those available to the public. The NRC would continue to maintain any pertinent records related to the decommissioning and license termination in the same docket file that was

used for the operating site. This approach should result in a continuous and completely documented history of the site operations, decommissioning, and license termination in a single file that will improve the efficiency and effectiveness of future search and retrieval of site information. These records are expected to be available to the public in the future. Also, NRC currently maintains (and expects to maintain in the future), a site decommissioning database, which includes restricted use sites. This publicly available database provides web-based access to general site information about all NRC decommissioned sites.

The site owner also would maintain any necessary records related to complying with the restrictive covenant and any monitoring and maintenance needed. Such records include the decommissioning plan, final status survey report, legal agreement (site owner at time of license termination), restrictive covenant, and correspondence between NRC and the site owner.

In accordance with the legal agreement, the licensee or site owner would be required to record the restrictive covenant with the appropriate recordation body responsible for maintaining records related to land ownership (e.g., Registrar of Deeds) in the jurisdiction where the site is located. In addition to the site owner, NRC, and the recordation body, other local and State groups or agencies [e.g., the State Department of Environmental Protection, local government agencies, civic groups, libraries (either physical locations or web-based information collection and storage systems)] could also preserve records. From time to time, it might be appropriate to hold public meetings or solicit input from the local community or affected parties about the site, to maintain a local awareness of the site and knowledge of the restrictions on site access and use. These recordkeeping responsibilities and knowledge management activities should be outlined in the LA/RC.

M.5 TOTAL SYSTEM APPROACH TO SUSTAIN SITE PROTECTION AT RESTRICTED USE SITES

Long-term effectiveness of institutional controls that would be required to restrict future site use is an important part of the overall LTR issue for institutional controls. Currently, all of NRC's decommissioning sites that are considering restricted use have radionuclides with long half lives such as uranium or thorium, and, therefore, would need long-term controls. Therefore, the purpose of this section is to explain NRC's approach for long-term protection. This section integrates many of the approaches described in the previous sections and presents them as a system to sustain protection.

In the Statement of Considerations for the LTR, the Commission recognized that requiring absolute proof that institutional controls would endure over long periods of time would be difficult, and the Commission did not intend to require this of licensees. Rather, the Statement of Considerations explained that institutional controls should be established with the objective of lasting 1000 years to be consistent with the time-frame used for calculations, and these controls would be expected to remain effective into the foreseeable future. However, the LTR also included added assurances that the public would be protected. Therefore, protection of public

health and safety is provided by a total system of controls and assurances that is durable and provides defense-in-depth. The total system described below is based on the requirements of the LTR, descriptions in the Statement of Considerations for the LTR, new policy options for institutional controls described in the LTR Analysis (SECY-03-0069) and the Regulatory Issue Summary (RIS) for the LTR Analysis in RIS 2004-08, and decommissioning guidance in NUREG-1757.

NRC's total system for protection consists of six elements: (1) legally enforceable institutional controls; (2) engineered barriers; (3) monitoring and maintenance; (4) independent third party oversight; (5) sufficient funding; and (6) upper limits on dose (i.e., "dose caps") if institutional controls fail. In addition, potential involvement by State and local governments and the community can add to the process. Each of these elements is described below, including how it contributes to protection, how it sustains protection for the duration needed, and what entity is responsible.

M.5.1 Legally Enforceable Institutional Controls

Legally enforceable institutional controls are required by the LTR. Institutional controls are administrative/legal mechanisms such as deed restrictions, permits, zoning, government ownership, or even an NRC LTC license. Institutional controls also can include physical controls such as fences, signs, markers, or vegetation.

Institutional controls are intended to protect the public health and safety by preventing adverse site access and land uses so that the LTR dose criterion of 0.25 mSv/y (25 mrem/y) is not exceeded. Limiting exposure time or preventing groundwater or agricultural uses can prevent adverse exposure pathways to people.

NRC's risk-informed graded approach is used to select the appropriate grade or type of institutional control, based on duration and magnitude of the hazard, so that restrictions are appropriately targeted using risk insights. Dose assessments are used to tailor site-specific restrictions to avoid adverse land uses.

Durable institutional controls, such as government ownership or control, could be used for higher risk sites with longer duration or higher magnitude hazards, to provide additional assurance of sustaining protection over the time period needed. Under new NRC policy, two options are available to provide durable institutional controls using either a NRC LTC license or a legal agreement and restrictive covenant, where NRC would have a monitoring and enforcing role.

Maintaining institutional controls is the responsibility of the owner or contractor to the owner, referred to as the custodian. The custodian also is responsible for conducting five-year reviews for higher risk sites to ensure the institutional controls are in place and continue to function. These reviews would include onsite inspections to verify that prohibited adverse activities are not

being conducted. The custodian would also maintain records and make them available to the public.

Institutional controls also are required by the LTR to be legally enforceable by an entity other than the custodian (e.g., local government, courts) that has the authority to enforce the particular type of institutional control. This entity would need to be identified and potential corrective actions described in the event the controls fail. Sustaining protection is also addressed by having legal opinions of the State or locality submitted to NRC to demonstrate that the institutional controls can be enforced and will be binding on future owners.

M.5.2 Engineered Barriers

Engineered barriers are man-made structures and can be a variety of types such as disposal cells, erosion protection covers, or cover layers to prevent or divert infiltration. These barriers are typically used to control adverse natural processes, such as erosion, that might expose contamination or infiltration of water that could cause release and migration of contaminants. Engineered barriers also can be designed to inhibit adverse human intrusion such as excavation and removal of cover material or contaminants.

The LTR does not require use of engineered barriers or specific designs that should be used, but the Statement of Considerations for the LTR recognizes that engineered barriers might be needed for sites with long-lived radionuclides. The LTR's performance-based approach allows flexibility for a licensee to determine if engineered barriers are needed to meet the LTR dose criteria and what contribution to performance might be needed considering how the barriers might degrade over time.

Although engineered barriers are not institutional controls, they can be used to supplement institutional controls and contribute to protection. In some cases, protection can be sustained for long time periods by using robust designs that do not rely on ongoing active maintenance. For example, erosion protection covers designed for up to 1000 years that have been used for uranium mill tailings sites may also have use at some decommissioning sites.

M.5.3 Monitoring and Maintenance

The site would be maintained by the custodian in accordance with the institutional controls. Monitoring and maintenance consists of identifying potential problems with institutional controls or engineered barriers and taking appropriate corrective actions to maintain the performance of the institutional controls or engineered barriers. Typically, monitoring could include a variety of activities such as visual surveillance or using instruments for radiological monitoring of surface or groundwater. Monitoring also could be used to detect indicators of potential future problems or measuring natural processes that could eventually impact the performance of the total system, unless corrected. Maintenance would include corrective actions to prevent disruptive processes that could result in non-compliance such as intrusion of covers by plants or burrowing animals,

or repair of fences and signs. A risk-informed graded approach is taken for both monitoring and maintenance to focus on disruptive processes and engineered barrier performance important to compliance. However, in such cases, the licensee should justify claims for long-term performance and consider in his justification the interaction between multiple barriers if more than one system is employed.

M.5.4 Independent Third Party Oversight

The LTR requires an independent third party to provide oversight to assure that the custodians' controls are performed and corrective actions are taken, as needed, to sustain the controls and maintenance. The independent third party also would act as a backup to the custodian to assume and carry out the responsibilities for control and maintenance, if needed. The independent third party could be a government entity, or even NRC (under its new policy for the LTC license or legal agreement/restrictive covenant) if other government entities do not accept this responsibility.

M.5.5 Sufficient Funding

The LTR requires that sufficient financial assurance be established to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site. A trust fund, or other financial assurance mechanism, would be established independent from the custodian and managed by a trustee. Sufficient funds would need to be placed into the trust fund to produce an annual income that is sufficient to cover (1) the annual average costs of controls, maintenance, and monitoring, if needed; (2) independent third party oversight costs; and (3) trustee fees and expenses. Thus, the fund balance would be sustained over time and not depleted because the annual costs of controls and maintenance are provided by the annual interest income.

M.5.6 Maximum Limits on Dose if Institutional Controls Fail

Because it is not possible to preclude the failure of controls, the LTR also requires that remediation be conducted so that there would be a maximum value, or "cap" on the dose if the institutional controls are no longer in effect. Compliance with the dose cap would prevent exposures in excess of the public dose limit of 1.0 mSv/y (100 mrem/y) or 5.0 mSv/y (500 mrem/y) under certain rare circumstances. These dose caps act as a safety net if institutional controls fail and, therefore, sustain protection by providing defense-in-depth.

Changes to NUREG-1757, Vol. 2, Section 3.5, “Use of Engineered Barriers”

3.5 USE OF ENGINEERED BARRIERS

The purpose of this section is to give guidance to licensees for considering the use of engineered barriers, including a risk-informed graded approach for selecting engineered barriers; engineered barrier analysis process; technical basis for engineered barrier performance; and potential performance and degradation mechanisms. This section also supports Section 17.7.3.2.2 by giving guidance on the information to be submitted in a decommissioning plan for the engineered barrier analysis and technical basis for engineered barrier performance.

In the Commission's view, engineered barriers, are distinct and separate from institutional controls (NRC 2002). Used in the general sense, an engineered barrier could be one of a broad range of barriers with varying degrees of durability, robustness, and isolation capability. Generally, engineered barriers are passive, man-made structures or devices intended to enhance a facility's ability to meet the dose criteria in the LTR. Engineered barriers are usually designed to inhibit water from contacting waste, limit releases of radionuclides (e.g., through groundwater, biointrusion, erosion), or to mitigate doses for inadvertent intruders. Institutional controls are used to limit inadvertent intruder access to, and/or use of, the site to ensure that the exposure from the residual radioactivity does not exceed the established criteria. Institutional controls include legal mechanisms (e.g., land use restrictions) and may include, but are not limited to, physical controls (e.g., signs, markers, landscaping, and fences) to control access to the site and minimize disturbances to engineered barriers.

The functionality and robustness of barriers would be determined using the risk-informed graded approach described in Section 3.5.1 and evaluated on a site-specific basis for each licensee application. However, this general framework that a licensee should consider would not vary from licensee to licensee, only the depth and breadth of information supplied to demonstrate the performance of the engineered barriers may vary. The guidance that follows provides the general framework a licensee should consider for use of engineered barriers in the decommissioning process. It is expected that engineered barriers will most frequently be used for restricted release sites. However, there may be infrequent cases where engineered barriers are used as one component of a decommissioning approach to achieve unrestricted release of a site. These cases should be infrequent because of the uncertainty associated with the long-term performance of engineered systems and because the goal should be to achieve unrestricted release without relying on engineered barriers.

Because of the wide range of residual radioactivity encountered at decommissioning sites licensed by NRC, the LTR and NRC's decommissioning guidance are not prescriptive as to the criteria for, or acceptability of, site-specific engineered barriers. Therefore, the licensee has flexibility in the methods used to demonstrate compliance with performance-based criteria of Part 20, Subpart E. Because of this flexibility and because engineered barrier designs are site-specific, it is very important for the licensee to clearly and completely document how the licensee has designed the engineered barriers and the monitoring and maintenance program for the site-specific conditions to maintain performance of the engineered barriers for as long as

necessary. The guidance that follows provides the framework for applying engineered barriers to achieve decommissioning at a site. These five sections are directed towards licensees pursuing restricted release, since it is envisioned that this is the situation where engineered barriers will most frequently be used. The guidance is directed towards designing new engineered barriers; however, it is recognized that some sites may have in-situ engineered features that are part of the existing site being decommissioned that the licensee wants to take credit for. In these situations, elements of Sections 3.5.2 and 3.5.3 may be most helpful. The guidance is intended to strike a balance between providing adequate direction without being overly prescriptive. Because the application of engineered barriers may be highly site-specific as a result of different radiological source terms, different exposure environments, and different natural systems, some elements of the guidance may not be applicable to every site.

In summary, NRC proposes that the following assumptions be used when applying engineered barriers to achieve decommissioning at a site:

- Engineered barriers are distinct and separate from institutional controls.
- Engineered barriers tend to be passive, man-made structures.
- Engineered barrier evaluation is completed on a case by case basis using a risk-informed approach.

3.5.1 Risk-Informed Graded Approach to Engineered Barriers

Initially, the general need for an engineered barrier(s) at a specific decommissioning site should be determined by considering if barrier(s) would be needed for compliance with the LTR dose criteria (e.g., mitigates the impact of natural processes such as erosion and infiltration). Once the general need is determined, a risk-informed graded approach should be used for selecting, designing, and providing a technical basis for the engineered barriers at a specific site. The risk-informed graded approach to engineered barriers is similar to the risk-informed graded approach for institutional controls described in Section M.2 of Appendix M that consists of a general risk framework and associated grades of institutional controls. The same risk framework is used for both institutional controls and engineered barriers and is defined by the hazard level and likelihood of hazard occurrence. The underlying philosophy is that robust engineered barriers and more basis for engineered barrier performance should be provided for higher risk sites. As described in Section M.2 of Appendix M, higher risk sites are those sites where the hazards are large (>1.0 mSv/y (100 mrem/y)when institutional controls are not in place) or when the hazard from the material is long-lived (e.g., >100 years), resulting in a longer performance period with higher likelihood of disruption and introducing the uncertainty of assessing performance over long temporal scales. Generally, “robust” means more substantial, reliable, and sustainable for the time period needed without reliance on ongoing active maintenance. The term “robust” is similar to the term “durable” used for institutional controls at higher risk sites (see Section M.2 of Appendix M). Section 3.5.6 provides a detailed example of the application of the risk-informed graded approach to engineered barriers for erosion protection.

Robust engineered barriers are also needed for sites where the hazards are being significantly mitigated by the functioning of a barrier (s) (i.e., risk reduction). 'Significantly mitigated' is site specific and can vary due to differences in the source and other features of the site (see example). In general, an engineered barrier that reduces the hazard more than a factor of 5 would likely be considered to be significant. The basis for this factor is that in many circumstances the uncertainty in the risk for restricted release sites can approach or exceed this value.

Although robust engineered barriers would generally be appropriate for higher risk restricted use sites, there is flexibility to also use robust engineered barriers as an approach to not rely on ongoing active maintenance at lower risk restricted use sites. Such an approach might simplify institutional controls and maintenance and thereby reduce costs for a licensee. In some limited cases, a robust engineered barrier also could be used at an unrestricted release site because the robust barrier has been designed so that its performance does not rely on active ongoing maintenance.

(Example) Site A and Site B both contain soil contaminated with equal concentrations of Sr-90. The primary exposure pathway is from leaching of the contamination to the groundwater pathway. Both sites design an engineered cap to limit infiltration for the next 100 years. Site A has a thick unsaturated zone composed of a clayey soil. The estimated travel time to the groundwater, constrained by observations of past releases of Sr-90, is at least 200 years. Site B has a thin unsaturated zone composed of a sandy soil and the estimated travel time to the groundwater is 60 years. There is no additional data to constrain the numerical estimate of the travel time at Site B.

Conclusion: Site B would need more technical basis for the performance of their engineered cap compared to Site A, because they would have less risk reduction from the natural system and their travel time estimate (which is directly tied to risk via radioactive decay) is more uncertain.

Specific grading of engineered barriers recognizes that the site-specific factors affecting risk can be highly variable from site to site. As a result, specific grading provides the flexibility to design barriers to achieve the desired functionality and robustness appropriate for a specific site.

Uncertainty related to engineered barrier performance over a long-temporal scale is also contextual in that the length of experience in the use of that type of barrier should be considered relative to how long-lived the contamination is. In general, hundreds to thousands of years would be considered long temporal scales for the application of engineered barriers to decommissioning, because it is almost certain that site specific experience for the performance of an engineered system does not extend beyond tens of decades. Section 3.5.2 provides guidance on how the barrier analysis process should be used to determine the performance of the engineered barriers. The risk-informed graded approach to engineered barriers is linked to the sections on effective barrier analysis (Section 3.5.2) and the technical basis for engineered barrier performance (Section 3.5.3), as well as Section17.7.2.3 of Vol. 1, Rev. 1, on maintenance and monitoring. For example, where there is a demonstration that the engineered barriers have been

designed to be robust and not reliant on ongoing active maintenance and repair, the amount of information and resources needed to support maintenance would be considerably reduced.

The robustness of an engineered barrier and the amount of technical basis provided for an engineered barrier should be consistent with the level of risk for a site (i.e., lower or higher risk) and the amount of risk-reduction provided by the barrier.

More robust engineered barriers and more technical basis would be needed for higher risk sites or where hazards at a site are significantly mitigated by the barrier.

Engineered barriers should be designed with the goal of remaining effective over the time period needed to achieve compliance, especially for long-lived radionuclides. The following items should be considered in designing engineered barriers for decommissioning sites:

- Designs should simplify long-term control and minimize the reliance on active ongoing maintenance and associated costs, especially for sites with long-lived radionuclides.
- Designs should mitigate potential future failures of the engineered barrier over the period needed to achieve compliance and the resulting need for and high cost of major repairs or replacement of major portions of the engineered barrier.
- Designs for sites with long-lived radionuclides, should place more reliance on natural materials and less reliance on synthetic materials that are less proven over the long-term. For sites with short-lived radionuclides, synthetic materials may be more advantageous because of less variability in the performance of the materials.
- Adequate financial assurance should consider the cost of monitoring, routine maintenance, and the need for potential major repairs of the engineered barrier over the time period of compliance should be provided.

3.5.2 Engineered Barrier Analysis Process

In order to implement a risk-informed graded approach, an accurate assessment of the performance of the engineered barriers should be provided. To determine compliance with Subpart E for restricted release, a licensee should complete, but not be limited to, an analysis of the following:

1. The contribution of engineered barriers towards compliance with the criteria of 10 CFR 20.1403 with institutional controls in place (including maintenance).

2. The contribution of engineered barriers towards compliance with the criteria of 10 CFR 20.1403 assuming loss of institutional controls (including loss of maintenance) such that the barrier may degrade over time.

The first analysis would typically evaluate a public receptor located at the site boundary prevented from accessing the site by the active institutional controls. The performance of the engineered barriers could include the benefit of active monitoring and maintenance to mitigate degradation while the institutional controls are in place and the dose limit would be 0.25 mSv/y (25 mrem/y).

The second analysis, that assumes loss of institutional controls, would typically include evaluating a reasonably foreseeable inadvertent intruder potentially located on the site. The dose limit applied to this receptor is 1.0 mSv/y (100 mrem/y) [or 5.0 mSv/y (500 mrem/y)]. The performance of the engineered barriers should consider the reasonableness of a breach by an inadvertent intruder and the potential degradation of the barriers over time because monitoring and maintenance are assumed to not be active. In addition, other reasonably foreseeable disruptive conditions from humans or natural events and processes should be evaluated. In some cases, the intruder may disrupt the engineered system that could result in higher doses through a different pathway (e.g., an agricultural intruder disrupts an engineered cap with plowing but does not disrupt the contamination directly.) Disruption of the cap could result in increased infiltration and higher groundwater pathway doses.

In regard to engineered barrier degradation, the licensee should address the two cases where maintenance is either in place or lost, because the assumption for loss of institutional controls includes the loss of maintenance of engineered barriers and physical controls such as fences or signs. It should be noted, however, that for those cases where an erosion control cover is designed in accordance with the uranium mill tailings guidance in NUREG–1623, a case might be made for a durable, long-lived engineered barrier that does not rely upon ongoing active maintenance (i.e., maintenance needed to assure that the design will meet specified longevity requirements) and associated future costs. For this case, no degradation of the erosion control cover would be assumed.

The barrier analysis process should be used to determine how much performance is being provided by the engineered barrier (i.e., risk reduction). To accomplish this, a licensee should perform analysis with the engineered system present and functioning. However for unrestricted release or when evaluating the loss of institutional controls (active monitoring and maintenance not performed), the barriers may degrade over time. An assumption of instantaneous failure of a barrier is not required. The goal is to clearly identify the expected benefit of the engineered barriers quantitatively in terms of dose reduction. The analysis should also address the uncertainty in the expected performance of the barriers. For example, a comparison could be made of the doses without engineered barriers present to the doses with engineered barriers performing as designed and expected, as well as more pessimistic performance and more optimistic performance. The assumption to model a degraded barrier is generally more realistic than the assumption of the absence of a barrier, and actually may lead to higher doses in some situations; for example, partial failure of a cover or partial failure of a grout wall system can focus water flow and can create a “bathtub” effect. Thus, simple on-off analyses (i.e., where the barrier is either assumed completely present or completely absent) should be used cautiously.

Caution should also be used when analyzing systems with multiple engineered barriers. When multiple barriers are present, the performance of one barrier may mask the potential contribution to performance of another barrier or may degrade its contribution. In these situations, the analysis may need to evaluate various combinations of barriers to determine the individual and cumulative contribution (positive or negative) to performance of the barriers. In particular, characteristics of one barrier that challenge or impair the performance of another barrier should be carefully assessed (e.g. increased filtration resulting from elimination of vegetation by inert covers). The type of analysis performed should be determined on a case by case basis. For the complex and higher risk decommissioning sites and those sites with long-lived radionuclides, the use of probabilistic analysis should be strongly considered. Deterministic analysis may not be able to adequately address the uncertainty in the calculations. However for simpler, lower risk sites and sites with short-lived radionuclides, deterministic analysis with sensitivity analysis may be sufficient. As indicated in Section 3.5.6.1, deterministic methods should be used for selection of the design flood for the development of long-term erosion controls.

In summary, the analysis of engineered barriers should identify and evaluate those conditions or processes that are adverse to performance and result in non-compliance. The following analysis should be provided:

- Analysis with institutional controls taking credit for monitoring and maintenance.
- Analysis assuming loss of institutional controls not taking credit for monitoring and maintenance.
- Analysis assuming loss of institutional controls (or unrestricted release) considering disruptive natural processes as well as reasonably foreseeable human disruptive processes to the barriers.

3.5.3 Technical Basis for Engineered Barrier Performance

Significant uncertainty exists concerning predicting the service life and long-term degradation rates of most engineered barriers. This section provides guidance on the main elements that should be provided to support the assessment of the performance of the engineered barriers in Section 3.5.2, including:

- The design, features, and functionality of the engineered barriers should be fully-described.
- Technical basis that the barriers will meet the dose criteria considering the degradation mechanisms should be provided, including consideration of combined and synergistic effects resulting from the real world conditions expected for the barriers (Section 3.5.4).
- Uncertainty in parameters and models used in the assessment of barrier performance and the design of engineered barriers.
- The suitability of numerical models for the estimation of engineered barrier performance should be provided.

- Parametric or component sensitivity analysis should be performed to identify how much degradation of the engineered barrier would result in non-compliance (see Section 3.5.2).
- Model support should be provided for the engineered barrier performance (e.g., analogs, experiments, simple engineering calculations to demonstrate reasonableness of the results).
- Quality assurance and quality control (QA/QC) should be provided for the design and analysis of engineered barriers.

Analysis can be used to understand the impact of uncertainty. For example, 1/4 loss of a cover may not result in non-compliance, but loss of 3/4 of a cover would. Then determine if reasonably foreseeable natural and human processes might cause a loss of 3/4 of a cover. This analysis approach may be an additional way to deal with the uncertainty due to lack of long-term cover degradation data.

Many engineered barriers are not amenable to model validation in the true sense, therefore multiple lines of evidence are recommended. Model support can come in many different forms, including but not limited to: analogs, laboratory experiments, field experiments, formal and informal expert judgement, and engineering calculations to demonstrate reasonableness of the results (e.g., hand calculations when numerical models are used). The level of model support should be commensurate with the risk significance of the engineered barriers to achieving site decommissioning (see Section 3.5.1). If the level of performance needed for an engineered barrier is consistent with past experience at similar sites, and the engineered barriers have similar design and quality assurance, then the model support could be considerably less than for an engineered barrier with performance objectives that significantly exceed engineering experience. When considering engineering experience, care must be taken to ensure that the environmental conditions for the relevant degradation mechanisms are reasonably similar, since many degradation mechanisms can be very sensitive to the environmental exposure conditions.

For engineered barriers that must have very long-term performance (e.g., thousands of years), natural analogs should be considered. The greatest uncertainties stem from extrapolating the results of short-term tests and observations to long-term performance. Standard engineering approaches frequently implicitly assume that the initial conditions persist, however the actual application of a barrier more appropriately could be viewed as a evolving component of a larger, dynamic ecosystem (Waugh, 1997). For some types of engineered barriers, natural analogs might provide information as to the possible long-term changes to an engineered system, and can be thought of as a long-term, uncontrolled experiment. Evidence from natural analogs can help demonstrate that there are real world complements to the postulated numerical predictions.

Monitoring and maintenance might be needed in order to verify the effectiveness, durability, and service life of the engineered barriers. This monitoring involves both the environmental system surrounding the engineered facility that could be disruptive and the facility itself (See the risk-informed approach to monitoring in Section 17.7.2.3). Non-destructive monitoring technologies that included designed and emplaced sensors should be preferred to conventional post-failure

monitoring. Novel ideas such as introduction of special dyes and/or tracers within the engineered system may facilitate remediation of impending failures. The identification of these and other measurable performance indicators within a monitoring strategy can be very important in extending the effective service life of these facilities. To the extent practicable, engineered barriers should be designed to support and simplify monitoring and maintenance.

3.5.4 Degradation Mechanisms and Functionality of Common Engineered Barriers

The purpose of this section is to identify for licensee consideration, the common engineered barriers, the degradation mechanisms for the common barrier types and materials, and typical functionality for these barriers. It is envisioned that this information may help staff or licensees select and design appropriate engineered barriers and understand the considerations that are needed for assessing long-term barrier degradation, so that the overall decommissioning process can be more efficient.

3.5.4.1 Common Barriers

The common barriers provided are those that may be encountered at a decommissioning site. Because technology evolves and a site may have unique considerations, this list should not be viewed as comprehensive. Engineered wasteforms are not explicitly listed as a common barrier for decommissioning, because in most instances a decommissioning site is dealing with contamination of environmental media and not explicit engineering of a wasteform. The assessment of engineered wasteforms has been addressed in low-level waste disposal and that guidance should be considered with respect to wasteforms used in decommissioning (NRC, 1991). Lists of common barriers that may be used at decommissioning sites and their primary functionality are:

- Engineered Caps — Multi-layered and composite engineered caps are typically used to limit infiltration, provide for shielding between the contamination and potential receptors, eliminate exposure scenarios, and to limit erosion.
- Geomembranes — Geomembranes are synthetic materials use primarily to limit infiltration to the contamination.
- Concrete/cement/grout — Engineered cementitious materials are typically used to stabilize contamination, provide a chemically favorable environment for retention of radionuclides, limit water contact, prevent erosion, provide shielding, and limit potential intruder contact with the contamination.
- Vertical barriers — Vertical barriers may be soil-bentonite, soil-cement-bentonite, cement-bentonite, sheet pile (steel or high-density polyethylene [HDPE]), and clay barriers and are primarily used to control the horizontal migration of groundwater.

- Permeable reactive wall — A contaminant plume is channeled between impervious vertical walls, referred to as the funnel, and flows naturally through a permeable reactive barrier gate, where the pollutants are treated in situ during the flow process.
- Interceptor trenches — Used to intercept and collect contaminant releases. Typically only applicable with monitoring and maintenance.
- Chemical barriers — Chemical barriers are used to modify subsurface environmental conditions (e.g., pH, Eh) to limit the solubility of radionuclides or to provide a more favorable geochemical environment for sorption. A good example are engineered cementitious materials (see above). Because of the diverse type of chemical barriers that could be applied, the degradation mechanisms and typical levels of functionality are not provided in the following sections but would need to be evaluated on a case by case basis.

3.5.4.2 Degradation Mechanisms

The degradation mechanisms provided may not be comprehensive due to the large variability in conditions and processes from site to site, but they should represent the main degradation mechanisms typically encountered. Degradation mechanisms depend on both the barrier and site-specific conditions. When evaluating degradation mechanisms, careful consideration should be given that the environmental conditions assumed or used in an analysis of long-term performance are representative of the in-situ conditions expected for the engineered barrier.

The main degradation mechanisms are described below for the different engineered barriers.

Degradation of Cement-Based Engineered Barriers

The major environmental degradation processes that affect cement-based engineered barriers are sulfate attack, corrosion of reinforcing steel/carbonation, alkali/aggregate reactions and leaching by acidic subsurface water. Other degradation mechanisms include freeze-thaw deterioration, and microbiological attack. Degradation mechanisms can also be due to poor design and construction of cement-based structures, and can include differential settlement of the structures; stress concentrations; seismic effects; and insufficient structural engineering design. To avoid these latter degradation mechanisms, the structures need to be properly designed, and constructed under strict QA/QC procedures to ensure that their design objectives have been met. Discussions that follow will not address these design and construction-related degradation issues of cement-based materials.

Sulfate Attack

Sulfate attack on concrete can be severe, resulting in cracking of the concrete, and in some cases, its disintegration. Naturally-occurring sulfates of sodium, potassium, calcium and magnesium are sometimes found in subsurface water and soils. Sulfate attack has occurred in several regions of the U.S., particularly in arid regions such as the Northern Plains and the Southwest States. Localized sources of sulfates in groundwater include mine workings, mine tailings, blast furnace

slag waste piles, and chemical waste ponds. Water used in irrigation can also be a potential source of sulfate attack due to the gradual accumulation of sulfates in the soils. The main cause of sulfate degradation of cement-based materials is the formation of ettringite in the reaction process. This results in the mechanical expansion and subsequent deterioration of concrete. Another degradation process involves the formation of gypsum which replaces the calcium hydroxide in concrete resulting in expansive stresses and deterioration.

Corrosion of Reinforcing Steel

Cement concrete normally provides a high-alkaline environment which passivates the steel. However the corrosion of steel embedded in concrete has been a serious problem due to the presence of chloride ions. Although chloride ions are common in nature, and small amounts are intentionally added in the mix ingredients of concrete to accelerate set times, the principal sources of chloride ions which cause problems in concrete are from deicing salts, sea water, and chloride ions in surface runoff. Corrosion of reinforcing steel can, in some cases, occur in the absence of chloride ions. This happens in the case of carbonation which results in a reduction of alkalinity of the concrete, thereby depassivating the steel and facilitating corrosion.

Alkali-Aggregate Reactions

Alkali-aggregate reactions are usually internally contained in concrete, and are not dependent on the diffusion of an aggressive solution into the cement-based material. For appreciable amounts of swelling to occur due to this process, a source of water is required. Almost all aggregates react to some extent with alkalies in cement. It is when the reaction results in the formation of expansive products (e.g., gypsum) that serious cracking of the concrete occurs. Expansive alkali-aggregate reactions are known to occur when siliceous (i.e., alkali-silica reactions) and dolomitic (i.e., alkali-carbonate reactions) limestone aggregates are used. In addition, the rate of expansive reaction is also influenced by the size of the aggregates. Alkali-silica reactions are the most common with the majority of the reported instances in the western states. Alkali-carbonate reactions have occurred in some Midwestern and Eastern states.

Leaching

Buried concrete, in contact with percolating subsurface water, can undergo deterioration by the dissolution of the common constituents of cement paste, the alkali salts and sodium hydroxide. Leaching can reduce the pH of the concrete, as well as make it more porous for subsurface water. The rate and extent of the leaching is dependent on the acidity of the water since leaching increases as the pH decreases. The potential leaching capabilities of subsurface water can be related to their Langelier Index. The Langelier Index is related to the total dissolved solids (TDS), total alkalinity, pH and calcium content of the water. A positive index indicates that calcium carbonate will be precipitated, while a negative index indicates lime deficient water capable of dissolving calcium from the hardened cement paste.

Freeze-Thaw Attack

Freezing and thawing damage in cement- based materials occurs when a water-saturated concrete is exposed to prolonged cycles of freezing and thawing. Structures most susceptible to freeze-thaw damage are surfaces of the structures where flowing or ponding water can remain in contact with the concrete structure for extended periods of time. Several precautions should be taken to avoid freeze-thaw damage, including the following: precluding ponded water from the concrete structure, incorporating entrained air, placing properly, consolidating, and curing.

Microbiological Attack

Sulfate-producing bacteria are capable of oxidizing elemental sulfur and sulfides to sulfuric acid under aerobic conditions, which in turn degrade cementitious materials. Some bacteria can attack cement-based materials by transforming ammonia into nitrites or nitrates, or by producing lactic acid or butyric acid. In the normal design life (e.g., 40 years) of conventional cement-based materials, bacterial action does not seem to be a major cause of deterioration. However, for cement-based materials' chemical durability over hundreds of years, the impacts of bacterial activity need to be assessed, though they may be difficult to predict.

Cracking of Concrete

Cracking can originate within concrete due to a number of mechanisms. During placement, if the evaporation rate is great enough, the concrete surface can develop tensile stresses sufficient to crack the concrete. These plastic-shrinkage cracks typically extend through the entire concrete member. Cracking can also be caused by settlement of the concrete member, by flexural stresses, and thermal effects. The continued removal of water by the hydration process will generate a chemical-shrinkage stress that can initiate autogenous shrinkage cracks. Subsequent drying due to ambient conditions will also generate shrinkage stress which generates drying-shrinkage cracks. Absent environmental conditions which may cause concrete-material degradation, cracking can be the most severe degradation mechanism affecting concrete. Transport through cracks in concrete will only be of consequence, if the cracks extend throughout the concrete member. Relatively large amounts of water can be transported through a crack depending on the total potential water-head across the full penetrating crack, and the crack aperture and density.

Degradation of Engineered Soil Caps

Engineered caps or covers are designed to eliminate or significantly limit infiltration of subsurface water into the waste. Engineered cap designs have a wide range of configurations ranging from a one-layer system of vegetated soils, to complex multi-layered designs composed of soils and geosynthetics. Soil materials can include in addition to vegetative soils, permeable sand and gravel drainage layers, low hydraulic conductivity clay soils, and filter soils to preclude the migration of fines from soils overlying drainage layers and causing them to be clogged. Geosynthetic materials include geomembranes (GM) and geosynthetic clay layers (GCL).

Composite barriers use both soils and GM/GCLs. GMs are essentially impermeable PVC or polystyrenes layers, while GCLs are composed of a thin layer of bentonite between two geosynthetic textiles which may be used in conjunction with GM's. The effectiveness of these engineered caps lies in its ability to significantly limit infiltration of subsurface water into the waste. This ability to drain infiltrating water away from the buried waste, and its ability to release generated gas is a function of the waste stability, non-settlement, and slope stability of the cap system. Degradation mechanisms unique to engineered cap materials, other than those specific to inadequate design, construction, QA/QC issues, follow:

Compacted Clay Barrier

The function of the clay barrier layer in the engineered cap is to prevent and block infiltration of subsurface water through the cover into the waste. In order to meet this function, the clay must always remain close to saturation. The compacted clay layer is frequently specified to have a saturated hydraulic conductivity of 10E-07 cm/sec or less. The longevity and effectiveness of the engineered cap are influenced by the ability of the clay layer to retain low permeability characteristics. However laboratory and field studies have shown that dessication (severe drying) cracks can form quickly in compacted clay. These cracks which do not completely self heal, can penetrate the entire thickness of the clay layer, and are not filled by soil from overlying layers in the time frame of available field studies (less than 10 years). The cause for extensive dessication of the clay is thought to be due to vertical water vapor transport.

Drainage and Filter Soil Layers

A common degradation mechanism affecting these drainage and filter components of the engineered cap system is the potential clogging of these materials by finer soil particles from overlying soils. Clogging of drainage/filter soil layers can greatly reduce the permeability of these materials, and render them unable to perform their intended function to drain subsurface water.

Composite Soil Caps

Composite caps are comprised of a combination of a compacted clay layer, GCL and GM. These composite caps have performed very well in the time frame of available field studies (10+years). GM's protect clay barriers/GCL's by eliminating or significantly reducing vertical water vapor migration. Degradation mechanisms of GM's include: puncture by granular soils and construction equipment; behavior of "waves" or fabric wrinkles due to temperature and overburden stresses; long-term degradation of GM's under the influence of UV light, chemicals and radiation effects; the potential for slippage between GM's and adjacent materials; and material embrittlement over time. GCL's are now frequently used instead of compacted clay, and seem to perform better with respect to water flow, chemical degradation due to cation exchange, and mass transport (i.e., diffusion and retardation). As with GM's however, GCL's have inherent problems due to installation activities (e.g., puncturing and degradation by construction equipment). However, recent research seems to indicate that there exists the

potential for cation exchange between commonly available calcium-laden fluids and the sodium in the GCL bentonite, thus rendering the GCL incapable of functioning as a low-permeability barrier layer in an engineered-cap systems. Research is being conducted to more carefully studying this degradation mechanism.

Degradation of Erosion Control Caps

Degradation of erosion control caps are discussed in Section 3.5.6.4.

Degradation of Permeable Reactive Barriers

Permeable Reactive Barriers (PRB) are in-situ constructed walls below the land surface that intercept contaminated groundwater which is funneled through it. Reactive materials in the wall can sorb chemicals and radioactive species on their surfaces and/or precipitate contaminants dissolved in the flowing water. In some cases nutrients and oxygen in a PRB help microbes in the soil to precipitate contaminants and radioactive species. Experience with PRB's seem to indicate that not all of them are performing well, often due to poor placement in the ground-water flow field. Material properties such as grain size of reactive zeolites can be changed in the construction process, thereby reducing their hydraulic conductivity. There seems to be a decrease of PRB performance due to loss of reactivity and permeability over relatively short periods of time (less than 5 years).

Degradation of Vertical Barriers

Various types of subsurface vertical barriers are in use. Their primary purpose is to impede or preclude horizontal ground-water flow. These vertical barriers are placed at depths up to 60 m (200 ft), and often vary in thickness from 0.6–1.2 m (2–4 feet). The barriers must extend down to an impermeable natural horizontal barrier such as a clay zone to effectively impede ground-water flow from below. These barriers are often designed as temporary or semi-permanent remediation techniques to isolate contaminated fluids from migrating to uncontaminated surrounding groundwater. Some soil-bentonite mixtures are not able to withstand attack by chemicals such as strong acids, bases, salt solutions and certain organic chemicals. This hastens the deterioration of the barrier. Verification that the vertical wall forms a continuous barrier is critical to the function of this technology. Although it may be difficult to identify flaws in the continuity, and/or gaps in the wall, monitoring is essential to verify their performance. Although vertical walls have been used for decades, the process of designing the proper mix of wall materials to contain specific contaminants is less well developed.

3.5.4.3 Potential Levels of Functionality and Uncertainty

The purpose of this section is to give some general information to help licensees initially consider the use of engineered barriers. As discussed in Sections 3.5.2 and 3.5.3, licensees are responsible for develop acceptable technical bases and conducting analyses of engineered barriers propose for a specific site.

The ranges of functionality or performance for different barriers and associated uncertainty are based on a broad consideration of observations and analysis throughout the national and international community. Potential ranges of functionality are levels expected that can be supported by a technical basis and analyses rather than demonstrated field experience. As the time scales get longer, past direct observation of the performance of engineered barriers that can be cited as basis becomes less likely and therefore performance for longer times becomes more uncertain and more based on inference. The functionality provided here can be thought of as the level of performance believed to be reasonably achievable with proper design, analysis (Section 3.5.2), technical basis (Section 3.5.3), and implementation (quality) given current understanding and engineering practice. The ranges provided for potential functionality, help provide direction as to when less technical basis may be needed (assume less than typical performance) compared to more technical basis (credit is taken for more than typical performance). The level of uncertainty should be considered in planning a monitoring and maintenance plan. Barriers with less uncertainty might need less reliance on monitoring and maintenance. In contrast, barriers with higher uncertainty, may need substantial monitoring and maintenance until uncertainties are reduced.

NRC's discussion in this draft section is an initial attempt using readily available information to provide some insights on potential functionality and uncertainty. This section could be expanded based on future studies and inputs from other programs involved with engineered barriers. Therefore, we invite suggestions and information that could further develop this section.

Typical levels of functionality or performance of the main engineered barriers are as follows.

Cement-Based Engineered Barriers

The performance of cement-based materials to isolate radioactive can be divided into two categories:

1. Hydrologic effectiveness or physical containment of the wastes to preclude water contacting the waste.
2. Chemical effectiveness or the ability of the high pH characteristics of the intact and degraded concrete to limit transport of the radionuclides to the accessible environment.

Absent environmental concrete degradation factors such as sulfate attack, chloride corrosion, etc., full depth cracking of the concrete member can be the most severe degradation mechanism causing contact of water to the waste and the subsequent release of radionuclides. Accordingly, the effectiveness of cement-based physical barrier structures need to be monitored for hydrologic effectiveness and the projected service life for the structure should be revised based on analysis of the monitoring data. Assuming adequate design, construction practices and excellent QA/QC followed by a competent monitoring program, service life of tens of years to a few hundred years appears feasible.

In the case of chemical containment of the wastes, given the high alkalinity of cement-based materials, the longevity of chemical effectiveness is dependent on the source term and specific radionuclide time frames (approximately 10 half-life periods). The timeframe of performance is difficult to predict, but could extend a significant period of time beyond the physical containment period.

A cementitious barrier used to limit potential intruder contact with waste, with proper design, construction practices, and QA/QC could be expected to be effective for hundreds of years if it remains unexposed to aggressive environmental conditions (e.g., high sulfate, excessive freeze-thaw cycles.).

Engineered Caps

Based on recent research experiences, extensive dessication of clay barriers in soil caps has compromised the ability of clay barriers to retain low permeability characteristics and preclude infiltration of water through the cover and into the waste (Albright, 2004). Conversely, composite caps composed of a combination of compacted clay buried at sufficient depth, geomembranes and geosynthetic clay liners have performed very well in the timeframes of available field studies (10+ years). Monitoring of caps composed of compacted clay barriers and composites can verify the effective lifetimes of these facilities. Given the good performance of composite covers, it is more probable that their functionality will be superior to compacted clay barriers. Current experience provides evidence of hydrologic functionality of tens of years for composite caps appear to be feasible. Longer hydrologic functionality may be feasible with the proper development and implementation elements provided in the previous sections. Existing uncertainty in long-term functionality could be reduced by additional technical basis, analyses, testing, or field experience.

Engineered caps developed for erosion control could have effectiveness that can exceed 1000 years. Section 3.5.6 provides a detailed example including some of the design considerations.

Aside from the depth to waste, most engineered caps would not provide a substantial barrier to common practices assumed in intruder analysis (e.g., home construction, well installation).

Permeable Reactive Barriers

There has been limited experience with permeable reactive barriers, approximately 15 years. Effective lifetimes of these barriers, from the literature, appear to be limited to less than 10 years.

Vertical Barriers

As noted previously, it is difficult to identify flaws in the continuity and gaps in constructed vertical walls. In addition, some of these walls are not able to withstand chemicals such as strong acids, bases, and certain organic materials. Moreover, the process of designing a proper mix of wall materials to contain specific contaminants (hazardous chemicals and radionuclides) is less well developed. Accordingly, effective service life of these structures would range in the low single digits of years and performance should be demonstrated by field testing.

3.5.5 Summary of Existing Guidance

Table 3.1 provides a summary of existing guidance that may have some relevance to the application of engineered barriers at decommissioning sites. Early contact with NRC staff is encouraged to discuss which portions of these referenced reports may be appropriate for the site and for the intended purpose of the engineered barriers. Guidance for design of engineered disposal cells for uranium mill tailings sites is provided in NUREG-1620 and NUREG-1623. For sites considering engineered disposal cells, this guidance may be somewhat useful. However, the standards in 10 CFR Part 40, Appendix A, applicable to uranium mills are more prescriptive than the performance-based dose criteria of Part 20, Subpart E. Licensees using the uranium mill guidance should also consider how the guidance can be adapted for applicability to compliance with Part 20, Subpart E.

Table 3.1 Summary of Existing Key Documents Related to Engineered Barriers

Document	Brief Summary
NUREG-1573, "A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities, Recommendations of NRC's Performance Assessment Working Group," U.S. Nuclear Regulatory Commission, Washington, DC, October 2000.	Provides general information pertinent to modeling and assessment of engineered barriers. Provides a bibliography of reports related to engineered barriers.
NUREG/CR-5432, "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes — Identification and Ranking of Soils for Disposal Facility Covers," U.S. Nuclear Regulatory Commission, Washington, DC, February 1991.	Discusses (1) selecting soil materials, (2) laboratory and field tests for covers, and (3) construction methods.
NUREG/CR-5542, "Models for Estimation of Service Life of Concrete Barriers in Low-Level Radioactive Waste Disposal," U.S. Nuclear Regulatory Commission, Washington, DC, September 1990.	Provides primarily empirically based models for typical concrete formulations to estimate degradation rates.
NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization," U.S. Nuclear Regulatory Commission, Washington, DC, September 2002.	Provides guidance on methods to achieve erosion controls for long-term stabilization. Provides a list of key references including the technical work supporting the guidance.
NUREG -1620, Rev. 1, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act," U.S. Nuclear Regulatory Commission, Washington, DC, June 2003.	Provides information regarding NRC staff areas of review and the bases for acceptability of a uranium mill reclamation design.
NUREG-1532, "Final Technical Evaluation Report for the Proposed Revised Reclamation Plan for the Atlas Corporation Moab Mill," U.S. Nuclear Regulatory Commission, Washington, DC, March 1997.	Section 4 provides an example of the staff review of a reclamation design and discusses staff bases for acceptability of rock riprap erosion protection and input parameters used for those designs.

Table 3.1 Summary of Existing Key Documents Related to Engineered Barriers

Document	Brief Summary
NISTIR 89-4086, NUREG/CR-5466, "Service Life of Concrete," National Institute of Standards and Technology (NIST) Gaithersburg, MD, 1995.	Examines degradation processes in cement-based materials and discusses considerations of their occurrence, extent of potential damage, and mechanisms.
NISTIR 7026, "Condition Assessment of Concrete Nuclear Structures Considered for Entombment," National Institute of Standards and Technology (NIST), Gaithersburg, MD, 2003.	Provides assessment of cement-based engineered barrier structures based on characterization of intact concrete and crack properties. Material property uncertainties are incorporated into a Monte Carlo simulation.
NISTIR 6747, "Validation and Modification of the 4SIGHT Computer Program" National Institute of Standards and Technology (NIST) Gaithersburg, MD, 2001.	Discusses the validation and verification of the fluid transport mechanisms incorporated in the concrete degradation code 4SIGHT using reference and laboratory data.
NISTIR 6519, "Effect of Drying Shrinkage Cracks and Flexural Cracks on Concrete Bulk Permeability," National Institute of Standards and Technology (NIST) Gaithersburg, MD, 2000.	Discusses a model for predicting both the width and spacing of flexural and drying-shrinkage cracks to estimate composite (intact and cracked) concrete structure permeability.
NISTIR 5612, "4SIGHT, Manual: A Computer Program for Modeling Degradation of Underground LLW Concrete Vaults, " National Institute of Standards and Technology (NIST) Gaithersburg, MD, 1995.	User Manual for numerical computer modeling of concrete degradation, 4SIGHT, to facilitate assessment of concrete vaults for isolating radioactive waste in Low Level Waste (LLW) disposal applications.
"Barrier Containment Technologies for Environmental Remediation Applications," edited by Ralph R. Rumer and Michael E. Ryan, John Wiley and Sons, 1995.	Review and evaluation of knowledge and practices of containment technologies suitable for remediation. Identifies areas where practical improvements could be developed. NOTE: It is expected that this document will be superseded by a more recent document on waste containment practices to be published in Fall 2005.

Table 3.1 Summary of Existing Key Documents Related to Engineered Barriers

Document	Brief Summary
National Research Council, National Academy of Sciences, "Barrier Technologies for Environmental Management," Summary of a Workshop, 1997.	Papers presented in the Workshop on the use of Engineered Barriers to prevent the spread of contaminants and its migration.
"Field Water Balance of Landfill Final Covers," Albright, W, Benson, C., Gee, G., Roesler, A., Abichou, T., Apiwantragon, P., Lyles, B., and Rock, S., Journal of Environmental Quality, 33(6), 2317-2332, 2004.	Results of large-scale field research study to assess the ability of landfill final covers to control infiltration into underlying waste.
"Assessment and Recommendations for Improving the Performance of Waste Containment Systems," U.S. EPA, EPA/600/R-02/099, 2002.	Discusses issues related to the design, construction and performance of waste containment systems used in landfills, surface impoundments and waste piles and in the remediation of contaminated sites.
National Research Council, National Academy of Sciences, "Research Needs in Subsurface Science," 2000.	Examines gaps in the understanding of the performance of subsurface facilities and recommends research needs in the area.
National Research Council, National Academy of Sciences, "Long-Term Institutional Management of U.S. DOE Legacy Waste Sites," 2000.	Discusses long-term management of DOE's waste sites and identifies characteristics and design criteria for effective long-term institutional management.

3.5.6 Example of the Risk-Informed Graded Approach for Erosion Protection Covers

The purpose of this section is to provide a detailed example of the application of the risk-informed graded approach to engineered barriers for erosion protection. While the example focuses on erosion control, the intent is to demonstrate the use of a risk-informed graded approach to the development and implementation of engineered barriers that would be applicable to the development of engineered barriers with different functionality (e.g., infiltration control).

3.5.6.1 Risk-Informed Graded Approach for Erosion Protection Covers

The risk-informed graded approach can be readily used for the design of an engineered barrier, specifically a soil or rock cover that is provided for erosion control. This approach provides significant flexibility and can be adapted for design of covers at a wide variety of sites with a wide range of waste inventories.

This section describes how the criteria provided in NUREG-1623, "Design of Erosion Protection Covers for Long-Term Stabilization," can be adapted to specifically implement erosion protection guidance for lower and higher risk decommissioning sites. This NUREG was chosen because the staff has used its suggested criteria to review and approve erosion protection designs at approximately 40 different uranium mill tailings impoundments.

Erosion control covers for uranium mill tailings impoundments were chosen because they provide examples of design and construction of robust engineered barriers for long-term protection of radioactive materials. Under the Uranium Mill Tailings and Radiation Control Act (UMTRCA), 40 CFR Part 192, and NRC's implementing regulations in 10 CFR Part 40, Appendix A, erosion control covers are required to be designed to remain effective for up to 1000 years without reliance on ongoing active maintenance. Although UMTRCA also requires State or DOE ownership and long-term care of the uranium mill tailings sites, including maintenance of the covers as needed, the covers are designed to function independently of maintenance. Therefore, the monitoring/surveillance and maintenance provided by DOE can be thought of as a backup to the robust design, or a defense in depth approach to long-term protection. Over 25 years of experience is available, including NRC's guidance and technical basis for design of robust erosion control covers and DOE's construction of these covers and monitoring of their performance. This program offers an approach and lessons learned for one kind of robust engineered barrier that could have some application to design of other types of robust barriers. Although the riskinformed graded approach to engineered barriers in this decommissioning guidance offers greater flexibility to select appropriate options for engineered barriers (including reliance on maintenance), the UMTRCA covers offer an excellent example of a robust erosion control barrier for higher risk sites with a long-term hazard.

Robust engineered barriers for erosion control should be designed, but a graded approach to the design should be taken with respect to selection of the design flood; evaluation of rock durability; and selection of appropriate design factors. Each of these three areas is described below.

Selection of Design Flood

One of the phenomena most likely to affect long-term stability is surface water erosion. To mitigate the potential effects of surface water erosion, the staff considers that it is very important to select an appropriate rainfall event on which to base the erosion protection designs. Further, the staff considers that the selection of a design flood event should not be based on the

extrapolation of limited historical flood data, due to the unknown level of accuracy associated with such an extrapolation. The Probable Maximum Precipitation (PMP) is computed by deterministic methods (rather than statistical methods) and is based on site-specific hydrometeorological characteristics. The PMP has been defined as the most severe reasonably possible rainfall event that could occur as a result of a combination of the most severe meteorological conditions occurring over a watershed. No recurrence interval is normally assigned to the PMP; however, the staff has concluded that the probability of such an event being equaled or exceeded during a 1000-year stability period is very low. Accordingly, the PMP is considered by the NRC staff to provide an acceptable design basis.

The Probable Maximum Flood (PMF) is based on the occurrence of the PMP and is considered to represent the most severe flood that can reasonably be expected to occur over a particular drainage basin. There is no probability assigned to the PMF, but the staff will generally not accept the use of statistically-derived floods, due to the unreliable extrapolation of flood records based on short-term data. Additional discussion of use of the PMP and PMF may be found in NUREG-1623.

Rock Durability

Rock durability is defined as the ability of a material to withstand the forces of weathering. Primary factors that affect rock durability are (1) chemical reactions with water, (2) saturation time, (3) temperature of the water, (4) scour by sediments, (5) windblown scour, (6) wetting and drying, and (7) freezing and thawing.

To assure that the rock used for erosion protection remains effective, potential rock sources are tested and evaluated to identify acceptable sources. In general, rock durability testing is performed using standard test procedures, such as those developed by the American Society for Testing and Materials (ASTM). The ASTM publishes and updates an Annual Book of ASTM Standards, and rock durability testing is usually performed using these standardized test methods.

A procedure for determining the acceptability of a rock source is presented in NUREG-1623 and generally includes the following:

- Test results from representative samples are scored on a scale of 0–10.
- The score is multiplied by a weighting factor, which focuses the scoring on those tests that are the most applicable for the particular rock type being tested.
- The weighted scores are totaled, divided by the maximum possible score, and multiplied by 100 to determine the rating.
- The rock quality scores are then compared to the criteria which determines acceptability.

After these tests are conducted, a overall rock quality score is determined. Rock scoring 80% or greater indicates high quality rock that can be used for most applications. Rock scores between 65%–80% indicate less durable rock that can also be used for most applications. Rock scoring less than 65% cannot be used for critical areas such as diversion ditches or poorly drained toes and aprons. Rock scoring between 50–65% can be used in non-critical areas such as well drained side slopes provided it is over-sized. Rock scoring less than 50% is not recommended for use in any application. Additional discussion may be found in NUREG-1623.

One of the more important tests conducted on a rock source is a petrographic examination to determine its overall acceptability. Particular emphasis is placed on selecting rocks that do have appreciable clay content or do not contain minerals that could rapidly weather to clays. The staff examined the causes of rock durability failures in typical applications such as placement on dam slopes or stream channels. In most cases, it was determined that durability failures were caused by the presence of expanding clay-lattice minerals, which, when exposed to moisture or freeze thaw cycles, caused the rapid deterioration of the rock.

Therefore, procedures for determining rock durability for long-term performance at decommissioning sites include criteria for the selection of rock sources that do no have clay minerals and do not have minerals that could weather to clays.

Selection of Appropriate Design Factors

In the selection of appropriate input parameters for calculating erosion protection size and thickness, it is important to choose values that reflect the degree of risk and the importance of the rock layer, as it contributes to overall stability. However, the selection of many input parameters to various models can sometimes be subjective and will need to be based largely on engineering judgment. Where there are large ranges in values, or where a parameter cannot be well-defined, or is not well-known, it has been the general policy of the NRC staff to accept the use of reasonable ranges and distributions of input parameters. For well-known or accepted parameters with narrow empirical distributions or very narrow ranges, expected values should be used as appropriate. For less well-known parameters, such as those based on little empirical data or with broad distributions, conservative values should be chosen from within the observed distributions or estimated range. In any case, there should a reasonable and defensible technical basis for the choice of a design basis event or design criteria, and the staff will accept values that can be justified. Otherwise, reasonably conservative values will be needed.

3.5.6.2 Erosion Protection Cover Analysis Process

At a lower risk site, where engineered barriers are needed to meet applicable requirements for only about 100 years and there is a lower hazard level should institutional controls and maintenance fail [up to the public dose limit of 1.0 mSv/y (100 mrem/y)], the principal design basis and goal is to assure the relative stability of the contaminated material by providing a cover design that maintains control of the material. Control of the material is achieved by providing a

relatively robust design that prevents offsite movement (e.g., erosion by natural forces) of the material. The rock erosion protection barrier could protect a second layer of material, for example one that might be a radiation shielding barrier or an infiltration barrier depending on the radionuclides at the site and natural processes important to achieving compliance with the dose criteria.

The design should be able to survive the occurrence of relatively rare events, and the erosion protection should be sufficiently robust to remain effective for about 100 years. Using the guidance and rationale contained in NUREG-1623 for a 100-year stability period, the barriers should be designed to resist a flood equivalent to either the regional historic flood of record or about half of the PMF, whichever is greater. The licensee should provide rainfall, flood, and erosion analyses that justify the design. A design that meets the suggested flooding and erosion protection criteria of NUREG-1623 is acceptable. The rock itself should be sufficiently durable to remain effective for at least 100 years by obtaining a rock quality score of at least 65. The computations and selection of input parameters should rely on reasonable and justified estimates.

For a higher risk site, with long-lived radionuclides or where failure of institutional controls and maintenance could result in a higher hazard of 1.0–5.0 mSv/y (100–500 mrem/y), the principal design basis and goal is to assure the control and stability of the contaminated material by providing a robust design that will remain effective for a period of 1000 years or more by preventing erosion by natural forces. These covers should be designed to maintain control and stability with no reliance on active maintenance. However, monitoring and maintenance will be conducted as a backup to provide defense-in-depth.

The staff could approve an engineered barrier design that is effective and maintains control of the material for a period exceeding 1000 years. Using the guidance and rationale contained in NUREG-1623, the barriers should be designed to resist severe localized rainfall events and large floods on nearby streams. The design rainfall event should be the PMP, and the design flood should be the PMF. A design that meets the suggested flooding and erosion protection criteria of NUREG-1623 is acceptable. The rock quality score should be at least 85, and selection of input parameters to various models should account for the unknowns associated with a very long stability period and the high-risk site.

For sites like this, if erosion is a significant issue and there are some uncertainties associated with the magnitude of this erosion, the staff will approve a design that would likely incorporate: (1) covers designed to resist erosion for a stability period exceeding 1000 years; (2) a long-term surveillance program that monitors the magnitude and rate of erosion; and (3) sufficient funding for the surveillance, repair, and replacement of some of the erosion protection. The staff will work closely with the expected long-term custodian to determine the amount of funding needed.

It is important to reiterate that the requirements of 10 CFR Part 40 are very prescriptive and may have precluded the use of many types of erosion protection designs. The staff considers that the design criteria suggested in NUREG-1623 may be used at decommissioning sites using approaches that were not necessarily used in uranium mill tailings applications. For example,

nearly all tailings sites were designed with disposal cell side slopes of about 1 vertical (V) on 5 horizontal (H). Based on the stability of erosion protection placed on much steeper slopes of stream channels, levees, and/or dam slopes, there is no reason why slopes steeper than 1V on 5H could not be used for the side slopes of disposal cells. The criteria in NUREG-1623 were not developed for use on specific slopes and may be adapted for steeper side slopes, as necessary. Minor changes to construction specifications, emphasizing careful rock placement on steeper slopes, may be the only added design consideration.

Table 3.2 summarizes the application of the risk-informed graded approach for the design of erosion protection for the sites discussed above.

Table 3.2 Summary of the Risk-informed Graded Approach for the Design of Erosion Protection Systems

Level of Risk	Flood Design Basis	Rock Durability Score	Confidence in Selection of Input Parameters
Lower	½ PMP / ½ PMF	> 65	Reasonable
Higher	PMP/ PMF	> 85	Very High

3.5.6.3 Technical Basis for Performance of Erosion Protection Covers

Soil and rock covers have been used extensively in the reclamation and stabilization of many uranium mill tailings sites. The requirements of 10 CFR 40 (active sites) and 40 CFR Part 192 (inactive sites) were met by NRC licensees and DOE by designing covers that would limit radon emissions for a period of 200–1000 years. The designs were sufficiently robust such that no active maintenance would be needed to achieve the required stability period. These designs generally consisted of a two-foot-thick soil radon barrier, covered with a layer of rock to prevent erosion.

The DOE and several NRC licensees had a great deal of success in designing and constructing these covers. The criteria of NUREG-1623 were applied, and several of the constructed sites could serve as models, particularly for sites in the southwestern United States. However, decommissioning sites may be located in more humid climates, necessitating the use of multi-layer thick soil covers as infiltration and erosion barriers. These soil covers are likely to be subject to erosion and disruption by various phenomena. See Section 3.5.6.4, below, for expected degradation mechanisms.

A strong archaeological basis exists to demonstrate the long-term stability of erosion protection materials. NUREG/CR-2642 presented substantial information to demonstrate the long-term survivability of various rock structures. NUREG-1623 provided information on long-term

weathering rates, based on observations of rock petroglyphs that could be dated to a period of nearly 1000 years before present. The rock durability scoring procedure was developed using data gathered from direct observations of rock quality and was based on the success achieved by DOE and licensees in actual construction. Further, observations of Native American burial mounds in West Virginia, Ohio, and Illinois serve to illustrate the survivability of earthen structures for long periods of time in the eastern United States.

The staff also has experience with rock durability failures at uranium mill tailings reclamation sites and at facilities constructed by other Federal agencies. These failures occurred, for example, when rock sources consisting of olivine basalts or granites containing significant feldspars were used. The staff reviewed the case histories associated with these failures (and other failures) and applied these lessons learned to develop the rock durability criteria suggested in NUREG-1623. As discussed above, these failures are generally related to the presence of expanding clay lattice minerals. In applying these lessons learned, the suggested criteria of NUREG-1623 suggest that no rock source should be selected where clay minerals are present or could be present. In conducting the petrographic examination, these criteria should always be applied when selecting rock sources for long-term performance at decommissioning sites.

3.5.6.4 Degradation Mechanisms for Erosion Control Covers

The erosion control cover at a typical decommissioning site could consist of either a rock layer or a soil layer and underlying rock layer. One of the most likely degradation mechanisms would be gully erosion. To account for that process, the design consideration that should be analyzed (and is considered by the staff to be the most likely) is the formation of a gully in the top soil cover, caused by surface erosion, flow concentrations, and/or the uprooting of large trees. The erosion should be assumed to continue and be deep enough to expose the rock layer, and thus the rock layer would need to be designed to resist further erosion and down-cutting of the gully. The licensee should design the soil cover, as described above, to be stable for rainfall events and runoff as large as the PMP/PMF. Further, the rock layer should be designed as a separate backup system for the soil cover and should also be designed for the PMP/PMF occurring in that gully, with flow concentrations produced by the growth of a drainage network to that gully. Further, the rock should meet the durability criteria suggested in NUREG-1623, with particular emphasis placed on the petrographic examination that indicates that no clay minerals are present (see Table 3.2).

References

Albright, W., Et al., “Field Water Balance of Landfill Final Covers,” Journal of Environmental Quality, 33(6), 2317–2332, 2004.

U.S. Nuclear Regulatory Commission, “Decommissioning Criteria for the West Valley Demonstration Project (M-32) at the West Valley Site,” Final Policy Statement, February 2002.

Waugh, W.J., et al., "Ecology, Design, and Long-Term Performance of Surface Barriers: Applications at a Uranium Mill Tailings Site," Presented in "Barrier Technologies for Environmental Management," Summary of a Workshop, National Research Council, National Academy of Sciences, 1997.

U.S. Nuclear Regulatory Commission, "Technical Position on Waste Form (Revision 1)," Division of Low-Level Waste Management and Decommissioning, Washington, DC, January 1991.

III ONSITE DISPOSAL OF RADIOACTIVE MATERIALS

The License Termination Rule (LTR) Analysis, SECY-03-0069 (NRC 2003), included discussion of the relationship between the license termination rule and the onsite disposal of radioactive materials under 10 CFR 20.2002. Following the LTR Analysis, the associated Regulatory Issue Summary (RIS) 2004-08 (NRC 2004) also provided a discussion of this issue. As a result of those two documents, the NRC staff added a new section to NUREG-1757, Vol. 1, Rev. 1, to provide additional discussion regarding the acceptable options for onsite disposal of radioactive materials:

- New Section 15.12, "Onsite Disposal of Radioactive Materials under 10 CFR 20.2002," is intended as a complete new section, so highlighting is not used.

The NRC staff plans a rulemaking effort, starting in fiscal year 2006, to address the prevention of future legacy sites. One of the important issues in preventing legacy sites is to ensure that sites have adequate financial assurance for decommissioning. The LTR Analysis included onsite disposal as one operational indicator of potentially increased decommissioning costs. Thus, the rulemaking will likely address additional financial assurance needs as suggested in Option 2 of the following draft guidance for onsite disposals. The NRC staff is specifically requesting comment (for guidance development and for early input to the rulemaking) on the issue of additional financial assurance for approval of onsite disposals, regarding (1) whether licensees desire or have a need for onsite disposals at higher dose criteria [i.e., up to 1.0 mSv/y (100 mrem/y)], (2) the appropriateness of additional financial assurance for onsite disposals at doses up to 1.0 mSv/y (100 mrem/y), and (3) general aspects of the issue.

New to NUREG-1757, Vol. 1, Rev. 1, Section 15.12, "Onsite Disposal of Radioactive Materials under 10 CFR 20.2002"

15.12 ONSITE DISPOSAL OF RADIOACTIVE MATERIALS UNDER 10 CFR 20.2002

15.12.1 Options for Onsite Disposals at NRC Licensed Facilities

NRC staff should use the following guidance for making decisions on specific license actions concerning onsite disposal of radioactive materials under 10 CFR 20.2002.

NRC regulations allow onsite disposals or burial of radioactive materials under 10 CFR 20.2002, and identify the information that must be included in the application. Additionally, the License Termination Rule (LTR) requires that the contribution to the dose from onsite disposals be reconsidered at the time of license termination. This suggests, at a minimum, that the LTR radiological criteria of 0.25 mSv (25 mrem/y) and ALARA for unrestricted use would apply. Also, since the timeliness rule applies to onsite disposals, licensees may have to reevaluate the dose contribution of approved onsite disposals before license termination.

The NRC staff's analysis of the LTR identified potential conflicts with onsite disposals and license termination dose criterion, and foresaw potential problems in meeting the dose criterion at license termination. NRC could approve an onsite disposal or burial of radioactive materials that would require remediation or decommissioning for license termination. The LTR Analysis identified several options for dealing with onsite disposals, and the Commission approved three performance-based options for onsite disposals that would be available to licensees under 10 CFR 20.2002. SECY-03-0069, Results of the License Termination Rule Analysis, and RIS-2004-08 provide additional background information on the three onsite disposal options discussed in this section.

The NRC staff believes that the three options allow adequate flexibility for onsite disposals at a variety of NRC-licensed facilities to meet the dose criteria in the current 10 CFR Part 20 requirements. The guiding principles in developing the guidance have been to allow flexibility within the current regulations and to prevent future legacy sites. Legacy sites are sites with complex decommissioning problems where typically funding is not available to adequately decommission the site for unrestricted use.

The three onsite disposal options that have been approved by the Commission are:

1. The NRC will continue the current practice of approving onsite disposal based on a dose criterion of a "few millirem." No additional financial assurance above the current requirements is needed.

2. The NRC will approve onsite disposal of radioactive materials with a dose criterion of 1.0 mSv/y (100 mrem/y) if additional financial assurance is provided to cover the cost of decommissioning the buried radioactive materials for license termination.

3. The NRC will approve onsite disposals with a maximum dose criterion of 0.25 mSv/y (25 mrem/y) without additional financial assurance for license termination if the radioactive material is mainly short-lived and will decay significantly in a few years as long as the likelihood of creating a legacy site is low (e.g., license termination is not imminent).

15.12.2 Acceptable Onsite Disposal Options

NRC staff should use the following guidance in the review of situations involving an onsite disposal. Radiation dose rate is the criterion for determining the need for additional financial assurance. The appendices in NUREG-1757, Vol. 2, provide guidance on applicable principles that should be used for site-specific dose modeling applications to support a 10 CFR 20.2002 request.

It is anticipated that onsite disposal will occur during the conduct of licensed operations, and will precede decommissioning and license termination. The onsite disposal options provide alternatives for dealing with radioactive waste generated during operations, and will allow flexibility for the management of radioactive waste or allow the licensee to defer offsite disposal until decommissioning for license termination.

15.12.2.1 Option 1

NRC will continue the current practice of approving onsite disposal based on a dose criterion of a "few millirem" per year. No additional financial assurance above the current requirements is needed. The "few millirem" per year criterion encompasses 0–0.05 mSv (0–5 mrem) per year TEDE.

Onsite disposal is permitted in accordance with 10 CFR 20.2002, which identifies in general terms the types of information necessary for NRC staff reviewers to determine if the proposed disposal is acceptable. This information includes the source term, identification of materials, physical and chemical properties of materials, site characteristics used for dose modeling, dose impacts, and ALARA considerations. Adequate information is needed to allow NRC reviewers to determine if appropriate dose and other analyses were done.

NUREG-1757, Vols. 1 and 2, addresses aspects of onsite disposal under 10 CFR 20.2002 that need to be considered by the licensee and NRC reviewers. Applications for onsite disposals of wastes containing mobile radionuclides (e.g., H-3 and C-14), that may reach subsurface soils and potentially reach groundwater, may need to provide detailed information on the design of any engineered structures or barriers used. The site geology and hydrology that is important to both containing the disposal area and the potential for radionuclide transport in the subsurface should be described.

15.12.2.2 Option 2

NRC will approve onsite disposal of radioactive materials under 10 CFR 20.2002 with a dose criterion of 1.0 mSv/y (100 mrem/y) if additional financial assurance is provided to cover the cost of decommissioning the buried radioactive materials for license termination.

Onsite disposals with a dose exceeding 0.25 mSv/y (25 mrem/y) require that additional financial assurance be provided for use in remediation of the site (e.g., removal of the buried materials) to unrestricted use criteria at license termination. The additional financial assurance should be adequate to remediate onsite disposals to prevent future legacy sites, including restricted use sites.

NRC staff should review the financial assurance available to the licensee to remediate or decommission an onsite disposal. Additional financial assurance may not be needed for some licensees for which ample decommissioning funds are already provided.

Typically, onsite disposals occur during facility operations when a specific date or time-frame for decommissioning and/or license termination may not be known. Licensees should consider the site life-cycle in developing an approach for onsite disposal of radioactive materials because the site must meet radiological criteria for license termination. Onsite disposals or burials may have to be remediated for license termination.

Onsite disposal is permitted in accordance with 10 CFR 20.2002, which identifies in general terms the types of information necessary for NRC staff reviewers to determine if the proposed disposal is acceptable. This information includes the source term, identification of the materials, physical and chemical properties of materials, site characteristics used for dose modeling, dose impacts and ALARA considerations. Adequate information is needed to allow NRC reviewers to determine if adequate dose and other analyses were done. Cost estimates should be provided for remediating the onsite disposals so the site meets the applicable radiological criteria for license termination.

NUREG-1757, Vols. 1 and 2, addresses aspects of onsite disposal under 10 CFR 20.2002 that need to be considered by the licensee and NRC reviewers. Applications for onsite disposals of wastes containing mobile radionuclides (e.g., H-3 and C-14), that may to reach subsurface soils and potentially reach groundwater, may need to provide detailed information on the design of any engineered structures or barriers used. The site geology and hydrology that is important to containing the disposal area and the potential for radionuclide transport in the subsurface soil should be described.

For materials licensees, NRC regulations on decommissioning timeliness require, in part, that within two years of permanent cessation of operations in any separate outdoor area that contains residual radioactive material such that the area is unsuitable for release in accordance with NRC requirements, a licensee must begin decommissioning or submit, within 12 months, a

decommissioning plan to NRC. NRC regulations also allow licensees to delay decommissioning or submission of a decommissioning plan if the delay is not detrimental to the public health and safety and is otherwise in the public interest.

Onsite disposals for materials licensees generally would be subject to the 2-year time frame discussed in the NRC regulations unless the NRC has approved an alternate schedule for completing the decommissioning of the onsite disposal. Therefore, under this Option 2, materials licensees that intend to dispose of material onsite in accordance with 10 CFR 20.2002 should consider requesting an alternate decommissioning schedule, as appropriate, and should use the guidance on alternate schedules in NUREG-1757, Vol. 3, Section 2.2.

15.12.2.3 Option 3

NRC will approve onsite disposals with a maximum dose of 0.25 mSv/y (25 mrem/y) without additional financial assurance for license termination if the radioactive material is mainly short-lived and will decay significantly in a few years as long as the likelihood of creating a legacy site is low (e.g., license termination is not imminent).

The mainly short-lived radioactive materials should have half-lives in the range of 120 day to a few years. The NRC financial assurance requirements exclude radioactive materials with half-lives shorter than 120 days. The half-life range is intended to include Co-60. Generally, it is anticipated that the materials disposed onsite will have decayed sufficiently by the time the site enters decommissioning that the radiological criteria for unrestricted use [0.25 mSv/y (25 mrem/y) and ALARA] can be met.

Typically, onsite disposals occur during facility operations when a specific date or time-frame for decommissioning and/or license termination may not be known. Licensees should consider the site life-cycle in developing an approach for onsite disposal of radioactive materials because the site must meet the LTR radiological criteria for license termination. Onsite disposals or burials may have to be remediated for license termination.

The basis for an onsite disposal is 10 CFR 20.2002 which identifies in general terms the types of information that will be necessary for the NRC reviewers to determine if the proposed disposal is acceptable. This information includes the source term, identification of the materials, physical and chemical properties of materials, site characteristics used for dose modeling, dose impacts and ALARA considerations. Adequate information is needed to allow NRC reviewers to determine if adequate dose and other analyses were done.

NUREG-1757, Vols. 1 and 2, addresses aspects of onsite disposal under 10 CFR 20.2002 that need to be considered by the licensee and NRC reviewers. Applications for onsite disposals of wastes containing mobile radionuclides (e.g., H-3 and C-14), that reasonably may be expected to reach subsurface soils and potentially reach groundwater, may need to provide detailed information on the design of any engineered structures or barriers used. The site geology and

hydrology that is important to both containing the disposal area and the potential for radionuclide transport in the subsurface should be described.

15.12.3 Miscellaneous Onsite Disposal Guidance Topics

15.12.3.1 Radiological Dose Assessment

NUREG-1757, Vols. 1 and 2, provided adequate guidance on the applicable radiological dose modeling that is needed to evaluate an onsite disposal or burial. The radiological dose assessment for onsite disposals will use a site-specific, realistic scenario that is applicable to decommissioning and license termination. The dose assessment for all options will need to demonstrate that the applicable dose criterion is not exceeded. The dose assessment for Option 2 is needed to determine the additional financial assurance that will be necessary to remediate the onsite disposal and allow for license termination. In reviewing an application for an onsite disposal, the NRC reviewer should be able to determine the TEDE at the time of license termination. An appropriate onsite disposal scenario may be a radiation worker exposure scenario unless public access is anticipated.

15.12.3.2 Recordkeeping

Pursuant to 10 CFR 20.2108, licensees are required to maintain records of disposals made under 10 CFR 20.2002. NUREG-1757, Vol. 3, provides guidance on recordkeeping requirements for licensees while they are conducting licensed operations. NRC expects adequate records of onsite disposals or burials to facilitate decommissioning and/or remediation at license termination.

15.12.3.3 Radiological Surveying and Monitoring

Licensees should perform applicable surveys and monitoring to assure that radioactive materials in onsite disposals are contained and maintained. For Option 1, it is expected that the radiation dose rates from an onsite disposal will not be distinguishable from natural-radiation background levels or from other site operations. Thus, for this option, a periodic surveillance of an onsite disposal area to ensure that it is not relocated or entered by an inadvertent intruder may be more appropriate.

15.12.3.4 Financial Assurance

NUREG-1757, Vol. 3, provides guidance on Financial Assurance requirements. Onsite disposal Option 2 above identifies the need for additional financial assurance to cover the cost of decommissioning or remediation of any onsite disposals that will exceed 0.25 mSv/y (25 mrem/y).

15.12.3.5 Licensed Materials Remaining Onsite

Typically, onsite disposal or burials occur during the conduct of licensed operations, and will precede any necessary remediation or decommissioning activities and license termination. The onsite disposal options will provide alternative approaches for dealing with onsite radioactive waste management or will allow the flexibility for management of radioactive materials intended for offsite disposal during the decommissioning process. Radioactive materials disposed onsite in accordance with 10 CFR 20.2002 may be allowed to remain in-place at license termination if the LTR criteria are met.

License applications for onsite disposal under 10 CFR 20.2002 generally should not include requests to leave contaminated structures in-place in contemplation of license termination. Those actions are better addressed in the decommissioning plan and in the license termination process.

15.12.3.6 Compliance with Environmental and Health Protection Regulations

An NRC licensee must comply with all applicable local, State, and Federal regulations governing any other toxic or hazardous properties of materials that may be disposed of under 10 CFR 20.2002.

IV SCENARIO JUSTIFICATION BASED ON REASONABLY FORESEEABLE LAND USE

The License Termination Rule (LTR) Analysis, SECY-03-0069 (NRC 2003), included discussion of the use of more realistic exposure scenarios to estimate potential doses to the public after termination of the license. Following the LTR Analysis, the associated Regulatory Issue Summary (RIS) 2004-08 (NRC 2004) also provided a discussion of this issue. As a result of those two documents, the NRC staff revised NUREG-1757, Vol. 2, to allow selection and justification of exposure scenarios based on reasonably foreseeable future land use:

- Chapter 5, "Dose Modeling Evaluations"

  Chapter 5 of Vol. 2 was revised to make the wording consistent with the approach to reasonably foreseeable future land use. Most of the changes to Chapter 5 of Vol. 2 are in Sections 5.2 and 5.3 and relate to reviews of critical groups, scenarios, and pathways. Some text was modified in the introduction. New or revised text is shown highlighted, and deleted text is shown as strikeout text.

- Section I.3 of Appendix I, "Criteria for Selecting and Modifying Scenarios, Pathways, and Critical Groups"

  Section I.3 of Appendix I of Vol. 2 was revised to reflect changes similar to those of Chapter 5. Changes focus on making the wording consistent with the approach to reasonably foreseeable future land use. Most of the changes are additions and are shown as highlighted text.

- Appendix M, "Process for Developing Alternate Scenarios at NRC Sites Involved in DandD and License Termination"

  Appendix M of Vol. 2 was revised to make the wording consistent with the approach for reasonably foreseeable future land use. The new text is shown highlighted.

Changes to
NUREG-1757, Vol. 2,
Chapter 5, “Dose Modeling Evaluations”

5 DOSE MODELING EVALUATIONS

~~The following chapter is taken directly from Chapter 5 of the SRP (NUREG–1727). There has been some minor editing to remove redundancy and to use consistent terminology in this document, but the essential information is the same. The scoping review has been revised to take into account the decommissioning groups.~~

INTRODUCTION

Nearly every licensee that submits a DP should provide NRC with estimates of the potential future dose that could be caused by the residual radioactivity remaining on the site after decommissioning activities are completed. The use of a dose limit allows both the licensee and regulator to take site-specific information into account in determining acceptable concentrations of residual radioactivity at the site using dose models and exposure scenarios that are as realistic as necessary. This part has been written to maintain this flexibility. It includes the evaluation findings and supporting detailed technical guidance necessary to review the licensee's dose and ALARA analyses. Guidance on information to be submitted is provided by decommissioning group in Volume 1 of this NUREG series.

NRC staff should review all of the dose modeling information submitted by the licensee. For certain cases, such as screening analyses using default values or a look-up table, most of the review has already been completed in developing these tools and, therefore, the licensee need only submit minimal site information and justification in using these models, parameters, and exposure scenarios. In addition, NRC staff should review the ALARA analyses, which is based, in part, on the dose modeling. Two general approaches exist to provide reasonable assurance that the final concentrations should meet the requirements of Subpart E:

1. The licensee can commit to the scenario(s), model(s), and parameters to be used to evaluate compliance with the dose criterion using the final concentrations. The licensee should project expected final concentrations in the DP to show that there is reasonable assurance that the dose criterion will be met at the time of license termination.
2. The licensee can derive and commit to nuclide-specific concentration limits equivalent to the dose limit.

The "Decommissioning and License Termination Framework" (Figure 1.2), which generalizes the entire decommissioning process (e.g., Step 7 includes FSS and other requirements related to license termination), provides the licensees with guidance on how to perform iterative dose analysis. NRC staff review divides dose modeling into four general parts:

1. the source term assumptions,
2. an exposure scenario considering the site environment,

3. the mathematical model/computational method used, and
4. the parameter values and a measure of their uncertainty.

The actions taken as part of the loop suggested by Steps 8 through 12 of Figure 1.2 can result in the licensee modifying one or more of the above four parts. Licensees, generally, should not, and do not need to, provide information on dose modeling iterations that are not the final dose analyses.

Other licensees may wish to include the iterative process as part of the DP. This is, generally, because site characterization is not complete enough to provide reasonable justification for assumptions used in modeling the site. Usually, such incorporation would be in the form of license conditions that need to be satisfied before license termination can occur.

For example, a site may have initial data on ground water contamination but, currently, does not have enough data on hydrological conditions to determine which survey units will be affected by the plume. Based on the limited data available, the licensee designates an area around the plume, and all survey units that involve that area will consider the dose from the ground water as part of the overall dose analyses. For the purposes of this example, NRC could require the licensee, through a license condition (or other mechanism), to continue to characterize its ground water. If the information validates that the area, affected by the ground water, is the same or smaller than the assumed area, the licensee can go forward with the decommissioning process. If the licensee wishes to take advantage of the smaller area, or the data points to a larger affected area, the licensee may need to submit a license amendment request to modify the FSS plan, the dose modeling, and any other area of the DP affected by the new assumed ground water-affected area (e.g., adding or subtracting survey units from the list that would consider ground water contributions in complying with Subpart E).

As described by Figure 1.2 and the preceding example, the areas of dose modeling, site characterization, and FSS~~es~~ are interdependent. This is an advantage, as judicious use of dose modeling can help guide site characterization. In addition, both site characterization and FSS can guide development of reasonable scenarios or modeling approaches. For example, the appropriate survey techniques may require more advanced modeling in some areas to make them cost effective to implement. Refer to Question 4 from Section O.1 of Appendix O of this volume, for information to clarify the development and use of input modeling values and to Section O.2.2 for lessons learned regarding dose modeling related to recently submitted decommissioning plans.

This chapter and the associated appendices use a number of different terms describing scenarios. Table 5.1 includes a description and comparison of these scenario terms.

Table 5.1 Comparison and Description of Scenario Terms Used in this Guidance

Types of Scenarios		Evaluation Purpose	Description/Example
Plausible	Screening	All can be compliance scenarios, used to demonstrate compliance with the radiological criteria of the LTR.	A predetermined scenario that can be used with very high confidence, for most facilities, to meet the radiological decommissioning criteria without further analysis. It includes conservative assumptions about land uses or behaviors. The screening scenario for residual radioactivity on building surfaces is building occupancy, and residential farmer for residual radioactivity in surface soils. These scenarios are not site-specific.
	Bounding		A scenario with a calculated dose that bounds the doses from other likely scenarios. The screening scenarios represent two bounding scenarios for site-specific analyses.
	Reasonably Foreseeable		Land use scenarios that are likely within the next 100 years, considering trends and area land use plans. These scenarios are usually site-specific.
	Unlikely	Not analyzed for compliance, but is used to risk-inform the decision	Land use scenarios that are plausible, based on historical uses, but are **not** likely within the next 100 years, considering trends and area land use plans (e.g., rural use of property currently in an urban setting). These scenarios are usually site-specific.
Implausible		No analysis required	Land uses that because of physical limitations could not occur (e.g., residential land use for an underwater plot of land).

GENERAL APPROACH FOR DOSE MODELING

The following section discusses the basic components that are involved in a dose modeling assessment. It is meant to provide an overview of how the pieces fit together. This discussion should provide both licensees and reviewers with an understanding of the "big picture," while the review components in the following sections focus more on NRC staff reviewing details of each part of the dose assessment.

Chapter 4 of this volume addresses characterization of the residual radioactivity currently present at the site and radiological surveys. The information is based on measurements and knowledge of the site history. To perform dose modeling, the licensee should use the site information on residual radioactivity expected to be present at the completion of decommissioning, to develop a

generalized view of the site's source term. In developing the source term model, the licensee should consider the site measurements, the intended remedial actions, and the needs of both the conceptual model and the FSS.

For example, a site may have a large number of both historical and current measurements characterizing the residual radioactivity over a 10-hectare (25-acre) site. If the site information shows that residual radioactivity levels do not vary significantly, the licensee may assume that the source term is a uniform layer of residual radioactivity over the site. If the site information shows that most of the residual radioactivity is concentrated in a small area of the site, which may be due to uneven contamination resulting from either a single source or multiple sources, then the licensee may visualize the site as two sources of residual radioactivity. For the purposes of dose modeling, the following are two sources of residual radioactivity:

1. a uniform concentrated source over the smaller area where the assumed concentration is based on that area's measurements; and
2. a second source that uniformly covers the rest of the affected area at some lower concentration.

After a source term model has been developed, the question becomes: "How could humans be exposed either directly or indirectly to residual radioactivity?" or "What is the appropriate exposure scenario?" Each exposure scenario should address the following scenario questions:

- How does the residual radioactivity move through the environment?
- Where can humans be exposed to the environmental concentrations?
- What is the likely land use(s) in the future for these areas?
- What are the exposure group's habits that will determine exposure? (e.g., What do they eat and where does it come from? How much? Where do they get water and how much? How much time do they spend on various activities?)

In most situations, there are numerous possible scenarios of how future human exposure groups could interact with residual radioactivity. The compliance criteria in 10 CFR Part 20 for decommissioning does not require an investigation of all (or many) possible scenarios; its focus is on the dose to members of the critical group for the compliance scenario. The critical group is defined (at 10 CFR 20.1003) as "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances." The compliance scenario is the scenario that leads to the largest peak dose to the average member of the critical group from the mixture of radionuclides. The compliance scenario may be based on a bounding scenario, such as, a screening scenario or another scenario using conservative assumptions about land uses or behaviors, or be based on the reasonably foreseeable land uses for the area.

By combining knowledge about the sources of residual radioactivity and the scenario questions, the analyst can develop exposure pathways. Exposure pathways are the routes that residual radioactivity uses to travel from its source, through the environment, until it interacts with a human. They can be fairly simple (e.g., surface soil residual radioactivity emits gamma radiation which results in direct exposure to the individual standing on the soil), or they can be fairly involved (e.g., the residual radioactivity in the surface soil leaches through the unsaturated soil layers into underlying aquifer, and the water from the aquifer is pumped out by the exposed individual for use as drinking water, which results in the exposed individual ingesting the environmental concentrations). Exposure pathways typically fall into three principal categories identified by the manner in which the exposed individual interacts with the environmental concentrations resulting from the residual radioactivity; the three principal categories are ingestion, inhalation, or external (i.e., direct) exposure pathways.

The exposure pathways for many of the exposure groups can be bounded by a smaller number of possible exposure groups. For example, at a rural site with surface soil residual radioactivity, two possible exposure groups are (1) a gardener who grows a small fraction of his or her fruits and vegetables in the soil and (2) a resident farmer who grows a larger fraction of his or her own food (i.e., the site supplies not only vegetables, but also meat and milk). In this case, the resident farmer bounds the gardener exposure group (because it both incorporates the gardener's pathways, but also includes other routes of exposure) and, therefore, the gardener exposure group does not need to be analyzed and the compliance calculation's scenario would involve the resident farmer.

As required by 10 CFR 20.1402, expected doses are evaluated for the average member of the critical group, which is not necessarily the same as the maximally exposed individual. This is not a reduction in the level of protection provided to the public but is an attempt to emphasize the uncertainty and assumptions needed in calculating potential future doses while limiting boundless speculation on possible future exposure scenarios. While it is possible to actually identify, with confidence, the most exposed member of the public in some operational situations (through monitoring, time-studies, distance from the facility, etc.), identification of the specific individual who should receive the highest dose some time (up to 1000 years) in the future is impractical, if not impossible. Speculation on his or her habits, characteristics, age, or metabolism could be endless. The use of the "average member of the critical group" acknowledges that any hypothetical "individual" used in the performance assessment is based, in some manner, on the statistical results from data sets (i.e., the breathing rate is based on the range of possible breathing rates) gathered from groups of individuals. While bounding assumptions could be used to select values for each of the parameters (e.g., the maximum amount of meat, milk, vegetables, possible exposure time), the result could be an extremely conservative calculation of an unrealistic scenario and may lead to excessively low allowable residual radioactivity levels.

Calculating the dose to the critical group is intended to bound the individual dose to other possible exposure groups because the critical group is a relatively small group of individuals, due to their habits, actions, and characteristics, who could receive among the highest potential doses

at some time in the future. By using the hypothetical critical group as the dose receptor, coupled with prudently conservative models, it is highly unlikely that any individual would actually receive doses in excess of that calculated for the average member of the critical group. The description of a critical group's habits, actions, and characteristics should be based on credible assumptions and the information or data ranges used to support the assumptions should be limited in scope to reduce the possibility of adding members of less exposed groups to the critical group. An analysis of the average member of the critical group's potential exposure should also include, in most cases, some evaluation of the uncertainty in the parameter values used to represent physical properties of the environment.

Use the definitions in Part 20 when calculating for compliance with the requirements of Subpart E. Use the Federal Guidance Report No. 11 (EPA 1988) when calculating internal exposures by using the intake-to-dose conversion factors, which are based primarily on adults. As stated in EPA's Draft Guidance for Exposure of the General Public (EPA 1994) which proposes a public dose limit of 1.0 mSv (100 mrem) per year from all sources:

> "These dose conversion factors are appropriate for application to any population adequately characterized by the set of values for physiological parameters developed by the [International Committee on Radiological Protection] and collectively known as "Reference Man." The actual dose to a particular individual from a given intake is dependent upon age and sex, as well as other characteristics. As noted earlier, implementing limits for the general public expressed as age and sex dependent would be difficult…. More importantly, the variability in dose due to these factors is comparable in magnitude to the uncertainty in our estimates of the risks which provide the basis for our choice of the [public dose limit]. For this reason EPA believes that, for the purpose of providing radiation protection under the conditions addressed by these recommendations, the assumptions exemplified by Reference Man adequately characterize the general public, and a detailed consideration of age and sex is not generally necessary." [sic]

Since age-based dose conversion factors are not being used, the same dose conversion factors are applied to all individuals. Only in rare scenarios will a non-adult individual receive a higher dose (i.e., take in more radioactive material) than an adult individual in a similar exposure scenario. One example is the milk pathway: children generally drink more milk annually than adults. If milk was the only pathway that would expose the individual to a dose, then the child would have a slightly higher dose than the adult. But in most situations, especially ones involving multiple pathways, the total intake of the adult is greater than that of a child. Therefore, for most multiple pathway scenarios, such as screening analyses, the average member of the critical group should usually be assumed to be an adult with the proper habits and characteristics of an adult. As the licensee eliminates pathways or modifies the scenario, the behavior and dietary habits of children may become important. In such cases, the licensees should consult with NRC staff for guidance.

By integrating the exposure scenario, source term, and knowledge about the applicable environmental transport routes involved in the exposure pathways, a conceptual model of the features and processes at the site can be created. The conceptual model is a qualitative

description of the important environmental transport and exposure pathways and their interrelationships. Using this description, a mathematical model quantifying it, or using an off-the-shelf computer code that implements the same (or similar) conceptual model, needs to be identified. Generally, a single mathematical model can be used for several different conceptual models by varying either the boundary conditions or the various parameters.

Going from a conceptual model to a mathematical model involves a number of assumptions and simplifications. For example, one part of a conceptual model of surface soil residual radioactivity involves the leaching of radionuclides through the soil and into the aquifer. In reality, the soil between the surface and the aquifer is usually formed by numerous layers of different types of soils with varying thickness across a site. For the purposes of dose modeling, the conceptual model is more focused on knowing how much activity is entering (and leaving) each major environmental compartment (such as the aquifer) than to precisely predict the level of activity in the intervening material (e.g., any single soil layer between the surface and the aquifer). Therefore, the mathematical model may view the intervening soil layers as one layer or just a few layers, depending on the difficulty of justifying effective parameters that will mimic the real behavior. Users of off-the-shelf codes should be aware of and consider the appropriateness of the assumptions made in the computer model they are using.

Selection of parameter values (or ranges) for features, events, and processes depends not only on the site conditions and the exposure scenario, but also on the computer code (or mathematical model) being used. Nearly any data set will need to be transformed into one appropriate to the situation. This can be as straightforward as generating a site-wide effective soil density value or as complex as converting resuspension factor data into resuspension rates. NRC has already factored these issues in the data used in the screening analyses, but licensees using site-specific information should justify their values.

In the past, the most common computer codes were deterministic and did not explicitly calculate parameter uncertainty. Although it is not always necessary for a licensee to use a probabilistic code to evaluate parameter uncertainty for site-specific analyses, licensees should provide some discussion of the level of uncertainty in the results. It should be noted that the type of uncertainty of prime interest to NRC staff is uncertainty in the physical parameters.

Licensees using probabilistic dose modeling should use the “peak of the mean” dose distribution for demonstrating compliance with the 10 CFR Part 20, Subpart E. Similar to all regulatory guidance, this NUREG report contains one approach for determining compliance with the regulations using probabilistic analyses. Other probabilistic approaches, such as “mean of the peaks” or other methods, if justified, may also be acceptable for demonstrating compliance. If the licensee intends to use any probabilistic approach to calculate DCGLs, the licensee should discuss their planned approach with NRC staff.

SCOPING REVIEW

As part of the DP review, NRC staff should evaluate the basis for each of the calculated doses used by the licensee in the various decommissioning options. NRC staff should organize this review by first looking at the overall scope of the dose modeling contained in the DP (possibly for several decommissioning options and/or critical groups). This scoping review should help NRC staff identify which specific dose modeling sections are applicable for a given DP. After the scoping review, NRC staff should review each of the scenarios that the licensee or responsible party is using to show compliance with the regulations.

An acceptable way to organize the scoping review is (a) to identify and confirm the principal sources (before and after remediation) of residual radioactivity and (b) to identify the decommissioning goal of the DP. Coupling the two sets of information, NRC staff should have a good indication of the appropriate sections. For decommissioning goals involving unrestricted release, NRC staff should quickly evaluate to what decommissioning group the licensee belongs. Section 5.1 is used for evaluating screening dose assessments for Decommissioning Groups 1–3. Section 5.2 is used for evaluating site-specific dose assessments for unrestricted release for Decommissioning Groups 4 and 5.

Next, NRC staff should first verify that conditions at the site are commensurate with the approach chosen by the licensee and the decommissioning group's requirements (i.e., whether the licensee may use a screening analysis approach or whether site-specific dose modeling should be performed). Licensees may not be able to use a screening analysis approach at sites exhibiting any of the following conditions (excluding those caused by sources of background radiation):

- soil residual radioactivity greater than 30 cm (12 in) below the ground surface,
- radionuclide residual radioactivity present in an aquifer,
- buildings with volumetrically contaminated material,
- radionuclide concentrations in surface water sediments, and
- sites that have an infiltration rate that is greater than the vertical saturated hydraulic conductivity (i.e., resulting in the water running off the surface rather than purely seeping into the ground).

These are limitations caused by the conceptual models used in developing the screening analysis. In other words, the conceptual model, parameters, and scenarios in the DandD computer code are generally incompatible with such conditions. Situations do exist where you can still utilize the analyses using scenario assumptions to modify the source term. For example, by assuming buried radioactive material is excavated and spread across the surface, the screening criteria may be applicable for use at the site.

When evaluating any decommissioning option that has a goal of terminating the license under the unrestricted release requirements of 10 CFR 20.1402, the primary scenarios generally involve individuals exposed on the site. ~~The default~~A licensee needs to evaluate scenarios consistent with the reasonably foreseeable land use over the next decades, or use a bounding scenario such as a resident farmer. In rare incidences, a scenario involving off-site use of residual radioactivity may be the critical scenario. A bounding exposure scenario for residual radioactivity in the environment (versus building surfaces) is usually some sort of residential farmer, because this group usually includes a nearly comprehensive number of exposure pathways. ~~S~~In addition to pathways that may be limited by land use assumptions, site conditions, such as soil type, or ground water quality~~ or other use scenarios~~, may remove potential exposure pathways from consideration with the appropriate level of justification by the licensee.

A decommissioning option that results in the license being terminated under the restricted use provisions of 10 CFR 20.1403 will require, at a minimum, two different exposure scenarios. One scenario should evaluate the performance of the proposed restrictions by assuming these restrictions never fail. Depending on where the residual radioactivity is and what the proposed restrictions are, the exposure location(s) for the critical group could be either onsite or offsite. The second scenario should be performed similarly to the analyses for unrestricted release, in which it assumes that the restrictions put in place by the licensee have failed to work properly (or effectively), and the site will be used without knowledge of the presence of residual radioactivity.

5.1 UNRESTRICTED RELEASE USING SCREENING CRITERIA (DECOMMISSIONING GROUPS 1–3)

NRC staff should review the information provided in the DP pertaining to the licensee's assessment of the potential doses resulting from the residual radioactivity remaining at the end of the decommissioning process. The findings and conclusions of the review under this chapter should be used to evaluate the compliance with the dose limit specified in Subpart E. This chapter addresses decommissioning options involving unrestricted release using the default screening models or derived tables. These will be licensees from Decommissioning Groups 1–3. Decommissioning Groups 4–7 may utilize the screening criteria described here as part of their dose modeling.

The evaluation criteria in this section on screening analyses have been divided into two categories based on the location of the residual radioactivity:

- Building Surface Evaluation Criteria, and
- Surface Soil Residual Radioactivity.

CALCULATION OF RADIOLOGICAL IMPACTS ON INDIVIDUALS

The overall objective of NRC staff's review is to determine if the screening criteria were used correctly by the licensee and whether the calculations provide reasonable assurance that potential doses would not exceed the dose limits. Specific impacts to be calculated include those associated with exposures using the default building scenario and model.

ACCEPTANCE CRITERIA

Regulatory Requirements

10 CFR 20.1402

Regulatory Guidance

- Appendix H of this NUREG report
- NUREG–1757, Vol. 1, "Consolidated NMSS Decommissioning Guidance: Decommissioning Process for Materials Licensees"

Information to be Submitted

NRC staff should organize this review by first looking at the overall scope of the dose modeling contained in the DP (possibly for several decommissioning options and/or critical groups). This scoping review, discussed in Chapter 5, should help the reviewers identify which review sections are applicable for a given DP. After the scoping review, NRC staff should review each of the scenarios that the licensee is using to show compliance with the regulations using the appropriate review section.

The licensee's dose modeling for building surfaces or surface soil using the default screening criteria should include both of the following:

- the general conceptual model (for both the source term and the building or outside environment) of the site, and
- a summary of the screening method (i.e., running DandD or using the look-up tables) used in the DP.

This information to be submitted is also included as part of the DP Checklist provided in this NUREG report (see Checklist Section V.a from Appendix D of Volume 1).

EVALUATION CRITERIA

When licensees use the default screening methods and parameters inherent in the DandD code by either running the computer code or using look-up tables, the review and acceptance of nearly all areas of the analysis have already been done by NRC staff in developing the screening tool and reviewers should only need to review the source term model and the overall applicability of using the screening method with the associated residual radioactivity.

NRC staff will determine the acceptability of the licensee's projections of (a) radiological impacts on future individuals from residual radioactivity and (b) compliance with regulatory criteria. The information in the DP may be considered acceptable if it is sufficient to ensure a reasonable assessment of the possible future impacts from the residual radioactivity on building surfaces or surface soil. The information should allow an independent staff evaluation of the justifications and assumptions used.

NRC staff should review the information identified in Sections 5.1.1 and 5.1.2, as necessary, for each dose assessment of residual radioactivity on building surfaces or surface soil that the licensee has submitted in the various decommissioning options. If the licensee did not directly calculate the dose from residual radioactivity, but instead derived, or proposed to use, unit concentration values, NRC staff may need only to review the information on the configuration of the residual radioactivity and the appropriate screening criteria section, below. Review of the spatial variability should be performed as part of the final survey. Detailed guidance is in Appendix H.

5.1.1 BUILDING SURFACE EVALUATION CRITERIA

- Source Term Configuration

  NRC staff should confirm that the actual measurements, facility history, and planned remedial action(s) support the source term configuration used in the modeling by reviewing the information in the facility history, radiological status, and planned remedial action(s) portions of the DP. The NRC reviewer should review both the areal extent of residual radioactivity and the depth of penetration of the residual radioactivity into the building surfaces. The NRC reviewer should determine if the physical configuration of the residual radioactivity can adequately be assumed to be a thin layer of residual radioactivity on the building surfaces. If the residual radioactivity is not limited to the building surfaces, then use of the default screening criteria are not warranted without additional justification. The NRC reviewer should reclassify the licensee as a Group 4 licensee and evaluate the modeling using Section 5.2.

- Residual Radioactivity Spatial Variability

  NRC staff should review the information provided by the licensee for conditions both before and those projected after the decommissioning alternative. Based on this information, NRC staff should determine whether it is appropriate to make an assumption of homogeneity (a) for the whole facility or (b) for subsections of the facility. NRC staff should then review the adequacy of the licensee's determination of a representative value (or range of values) for the residual radioactivity concentration in the source term modeled. To evaluate the final survey, as a general guideline, NRC staff could use the concepts related to area factors included in MARSSIM and in Section I.3.3.3.5 of Appendix I.

- Execution of the DandD Computer Code Dose Calculations

  If the licensee has used the DandD computer code to calculate the dose based on either current concentrations or projected final concentrations, NRC staff should verify that:

  1. The residual radioactivity is limited to building surfaces.
  2. If the appropriate annual peak dose is greater than 0.025 mSv (2.5 mrem), the removable fraction of the residual radioactivity is 10 percent or less at the time of license termination, or the removable fraction has been adjusted as explained in footnote a in Table H.1.[4]
  3. The output reports verify that no parameters (other than source term concentrations) were modified.
  4. The licensee has used the 90th percentile of the dose distribution to compare with the dose limit.

- DCGLs from the DandD Code or Look-up Tables

  The licensee may use either the DandD computer code or the published look-up table for beta and gamma emitters (see Appendix H) to establish radionuclide-specific DCGLs equivalent to 0.25 mSv/y (25 mrem/y).

  If the licensee is proposing to use radionuclide-specific DCGLs, NRC staff should verify that the following three conditions are true:

  1. The residual radioactivity is limited to building surfaces.
  2. If the residual radioactivity is greater than 10 percent of the respective screening DCGLs (Table H.1 from Appendix H of this volume), the removable fraction is 10 percent or less

[4] The DandD default scenario assumes that only 10 percent of the surface residual radioactivity is removable and available for resuspension. Only at 10 percent of the dose limit does the assumption begin to become important because in the extreme case of 100 percent removable, for radionuclides that produce the majority of dose from the inhalation pathway, the code result may be underestimating the result by a factor as great as 10.

at license termination, or the removable fraction has been adjusted as explained in footnote a in Table H.1.

3. If more than one radionuclide is involved, there is reasonable assurance that the sum of fractions (concentrations divided by DCGLs) (see Section 2.7) is no greater than 1.

If the licensee has used the DandD Version 2 computer code to calculate the radionuclide-specific DCGLs, NRC staff should also verify that the following two conditions are true:

1. The output reports verify that no parameters (other than entering unit concentrations) were modified.
2. The licensee has used the 90th percentile of the dose distribution to derive the concentrations.

- Compliance with Regulatory Criteria

The licensee's projections of compliance with regulatory criteria, if that decommissioning option is pursued, are acceptable provided that NRC staff has reasonable assurance that at least one of the following is true:

1. The only residual radioactivity is on building surfaces, and the level of removable residual radioactivity does not violate the assumptions in the model.
2. The final concentrations result in a peak annual dose of less than 0.25 mSv (25 mrem) and the licensee has committed to calculating the annual dose using a screening analysis at license termination.
3. The planned DCGLs are equal to or less than those provided by the screening criteria, and the licensee has committed to maintaining the sum of fractions, if applicable.

5.1.2 SURFACE SOIL EVALUATION CRITERIA

- Source Term Configuration

NRC staff should confirm that the actual measurements, facility history, and planned remedial action(s) support the source term configuration used in the modeling by reviewing the information in the facility history, radiological status, and planned remedial action(s) portions of the DP. The NRC reviewer should review both the areal extent of residual radioactivity and the depth of penetration of the residual radioactivity into the soil. The NRC reviewer should determine if the physical configuration of the residual radioactivity can adequately be assumed to be a layer of surface soil containing residual radioactivity without overlying surface layers. If the residual radioactivity is not limited to the surface soil, then use of the default screening criteria are not warranted without additional justification. The NRC reviewer should reclassify the licensee as a Group 4 licensee and evaluate the modeling using Section 5.2.

- Residual Radioactivity Spatial Variability

  NRC staff should review the information provided by the licensee for conditions both before and those projected after the decommissioning alternative is complete. Based on this information, NRC staff should determine whether it is appropriate to make an assumption of homogeneity (a) for the entire affected area or (b) for major subsections of the site. NRC staff should then review the adequacy of the licensee's determination of a representative value (or range of values) for the residual radioactivity concentration in the source term model. At the time of the final survey, as a general guideline, NRC staff can use the concepts related to area factors included in the MARSSIM and in Section I.3.3.3.5 of Appendix I.

- Conceptual Models

  Detailed NRC staff review of the information is not necessary as these topics were previously addressed by NRC staff establishing the default screening methods. NRC staff should verify that the site and DandD's conceptual models are compatible. Situations that would not allow the use of the DandD code as a screening tool for environmental concentrations of radionuclides would include those where the source is not predominantly present in the surface soil, residual radioactivity in the aquifer, or sites with infiltration rates higher than the vertical saturated hydraulic conductivity (i.e., resulting in surface runoff or a bathtub effect) without additional justification showing that the results would still calculate a conservative dose estimate. A complete list of screening values can be found in Appendix H.

- Execution of DandD Computer Code for Dose Calculations

  If the licensee has used the DandD computer code, NRC staff should verify that all of the following is true:

  1. The residual radioactivity is limited to surface soil.
  2. The total dose calculated includes all sources of residual radioactivity.
  3. The output reports verify that no parameters (other than source term concentrations) were modified.
  4. The licensee has used the 90th percentile of the dose distribution to compare with the dose limit.

- DCGLs from the DandD Code or Look-up Tables

  The licensee may use either the DandD computer code or the published look-up table (see Appendix H) to establish nuclide-specific DCGLs equivalent to 0.25 mSv/y (25 mrem/y). If the licensee is proposing to use radionuclide-specific DCGLs, NRC staff should verify that both of the following conditions are true:

  1. The residual radioactivity (for the action under review) is limited to surface soil.
  2. If more than one radionuclide is involved, there is reasonable assurance that the sum of fractions (see Section 2.7) will be maintained.

If the licensee has used the DandD Version 2 computer code to calculate the radionuclide-specific DCGLs, NRC staff should also verify that both of the following conditions are true:

1. The output reports verify that no parameters (other than entering unit concentrations) were modified.
2. The licensee has used the 90th percentile of the dose distribution to derive the concentrations.

- Compliance with Regulatory Criteria

  The licensee's projections of compliance with regulatory criteria (if the decommissioning option is pursued) are acceptable, if NRC staff has reasonable assurance of all the following:

  1. The licensee has applied an appropriate source term.
  2. The only residual radioactivity is surface soil.

The final concentrations result in a peak annual dose of less than 0.25 mSv (25 mrem) and the licensee has committed to calculating the annual dose using a screening analysis at license termination, or the planned DCGLs are equal to or less than those provided by the screening criteria, and the licensee has committed to maintaining the sum of fractions, if applicable.

5.2 UNRESTRICTED RELEASE USING SITE-SPECIFIC INFORMATION (DECOMMISSIONING GROUPS 4–5)

The following guidance is for reviewing DPs submitted by licensees from Decommissioning Groups 4 and 5.

AREAS OF REVIEW

NRC staff should review the information provided in the DP pertaining to the licensee's assessment of the potential doses resulting from exposure to residual radioactivity remaining at the end of the decommissioning process. The findings and conclusions of the review under this section should be used to evaluate the DP's compliance with 10 CFR 20.1402. NRC staff should ensure that, at a minimum, information on the source term, exposure scenario(s), conceptual model(s), numerical analyses (e.g., hand calculations or computer models), and uncertainty have been included. NRC staff should review the abstraction and assumptions regarding the source term, the conceptual model of the site or building as appropriate, the exposure scenario(s), the mathematical method employed, and the parameters used in the analysis and their uncertainty.

The amount of information provided by the licensee and the depth of the reviewer's investigation of that information will depend on the complexity of the case and the amount of site-specific information (versus default assumptions) being used by the licensee. This section has been

written for review of the most complex analyses; most analyses should not need in-depth review of all parts of the evaluation criteria.

REVIEW PROCEDURES

Acceptance Review

NRC staff should review the DP to ensure that, at a minimum, the DP contains the information summarized under "Areas of Review," above. NRC staff should review the dose modeling portion of the DP without assessing the technical accuracy or completeness of the information contained therein. The adequacy of the information should be assessed during the detailed technical review. NRC staff should review the DP table of contents and the individual descriptions under "Areas of Review" as shown above (a) to ensure that the licensee or responsible party has included this information in the DP and (b) to determine if the level of detail of the information appears to be adequate for NRC staff to perform a detailed technical review.

Safety Evaluation

The material to be reviewed is technical in nature, and NRC staff should review the information provided by the licensee to ensure that the licensee used defensible assumptions and models to calculate the potential dose to the average member of the critical group. NRC staff should also verify that the licensee provided (a) enough information to allow an independent evaluation of the potential dose resulting from the residual radioactivity after license termination and (b) reasonable assurance that the decommissioning option will comply with regulations.

ACCEPTANCE CRITERIA

Regulatory Requirements

10 CFR 20.1402

Regulatory Guidance

- Appendix I of this NUREG report
- NUREG–1549, "Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination"
- NUREG/CR–5512, Volume 1, "Residual Radioactive Contamination from Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent"

- Draft NUREG/CR–5512, Volume 2, "Residual Radioactive Contamination from Decommissioning: User's Manual"
- Draft NUREG/CR–5512, Volume 3, "Residual Radioactive Contamination from Decommissioning: Parameter Analysis"
- Federal Guidance Report Number 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988)
- Federal Guidance Report Number 12, "External Exposure to Radionuclides in Air, Water, and Soil" (EPA 1993)

Information to be Submitted

NRC staff should organize this review by first looking at the overall scope of the dose modeling contained in the DP (possibly for several decommissioning options and/or critical groups). This scoping review, discussed in Chapter 5, should help the reviewers identify which section is applicable for a given dose assessment. After the scoping review, NRC staff should review each of the scenarios that the licensee is using to show compliance with the regulations.

In describing the licensee's dose modeling analysis methods, "site-specific" is used in a very general sense to describe all dose analyses except those based only on the default screening tools. This may be as simple as a few parameter changes, in the DandD computer code from their default ranges, to licensees using scenarios, models, and parameter ranges that are only applicable at the licensee's site. The information submitted should include the following:

- the source term information including nuclides of interest, configuration of the source, areal variability of the source, and so forth;
- a description of the exposure scenario including a description of the critical group;
- a description of the conceptual model of the site including the source term, physical features important to modeling the transport pathways, and the critical group;
- the identification, description and justification of the mathematical model used (e.g., hand calculations, DandD v2.1, RESRAD v6.1);
- a description of the parameters used in the analysis;
- a discussion about the effect of uncertainty on the results; and
- input and output files or printouts, if a computer program was used.

This information to be submitted is also included as part of the DP Checklist provided in this NUREG report (see Checklist Section V.b from Appendix D of Volume 1).

EVALUATION CRITERIA

NRC staff should determine the acceptability of the licensee's projections of radiological impacts on the average member of the critical group during the compliance period from residual radioactivity. The information in the DP is acceptable if it is sufficient to ensure a defensible assessment of the possible future impacts from the residual radioactivity. The licensee's assessment can be either realistic or prudently conservative. The information should allow an independent NRC staff evaluation of the assumptions used (e.g., source term configuration, applicable transport pathways) and possible doses to the average member of the critical group.

NRC staff should review the following information, as necessary, for each dose assessment of residual radioactivity that the licensee has submitted in the various decommissioning options.

- Source Term

  NRC staff should review the assumptions used by the licensee to characterize the facility's source term of residual radioactivity for dose modeling purposes. NRC staff should compare the assumptions with the current site information and the decommissioning alternative's goal. The model should be an appropriate generalization of this information. Three key areas of review for the source term assumptions are the (1) configuration, (2) residual radioactivity spatial variability, and (3) chemical form(s). For additional guidance, refer to Section I.2 from Appendix I of this volume.

  1. Configuration

     NRC staff should confirm that the actual measurements, facility history, and planned remedial action(s) support the source term configuration used in the modeling by reviewing the information in the facility history, radiological status, and planned remedial action(s) portions of the DP. NRC staff should review the provided information for both the areal extent of residual radioactivity and the depth (for soil or buildings) or volume (for ground water or buried material) of the residual radioactivity. The NRC reviewer should determine if the information provided supports the configuration assumptions used in the exposure scenario and mathematical model (e.g., a thin layer of residual radioactivity on the building surfaces).

2. Residual Radioactivity Spatial Variability

   NRC staff should review residual radioactivity concentration values provided by the licensee for conditions both before, and projected after, the decommissioning alternative is complete. For this subsection, NRC staff should review the spatial extent and the degree of heterogeneity in the values. Based on this information, NRC staff should determine whether it is reasonable to make an assumption of homogeneity for each source for either (a) the whole site or (b) subsections of the site. NRC staff should then review the adequacy of the licensee's determination of a representative value (or range of values) for the residual radioactivity concentration in the source term model. At the time of final survey, as a general guideline, NRC staff could use the concepts related to area factors included in the MARSSIM and in Section I.3.3.3.5 from Appendix I of this volume.

   If the licensee has DCGLs as a result of dose modeling, instead of estimating final concentrations and then, entering them into the code, the licensee need not specifically address the spatial variability acceptance criteria at this time. The licensee should provide this information in the FSS for NRC staff review. NRC staff should verify that the spatial variability is compatible with the assumptions made for dose modeling.

3. Chemical Form

   The licensee's assumptions regarding the chemical form of the residual radioactivity should be reviewed for its adequacy by NRC staff. NRC staff should determine whether the licensee has considered possible chemical changes that may occur during the time period of interest. Without any justification of possible chemical forms, the analysis should use the bounding chemical form(s) (e.g., the chemical form(s) that give the individual the highest dose per unit intake as described in Federal Guidance Report Number 11 (EPA 1988)). Acceptable rationale for other assumptions should be provided by the licensee. Some acceptable rationales for using other chemical forms are (a) chemical forms that would degrade quickly in the environment (e.g., UF_6) or (b) the unavailability of an element or conditions to realistically form that molecule (e.g., $SrTiO_4$ or high-fired UO_2).

- Critical Groups, Scenarios, Pathways, Identification and Selection

  In its review, NRC staff should confirm that the licensee has identified and quantified the most significant scenarios based on available site- or facility-specific information. NRC staff should review the basis and justification for the licensee's selected critical group. For scenarios in which possible environmental pathways have been modified or eliminated, NRC staff should review the justifications provided by the licensee. For additional guidance on these subjects, refer to Section I.3 from Appendix I of this volume.

1. Scenario Identification

   The compliance exposure scenario is based on the location and type of source (e.g., contaminated walls), the reasonably foreseeable land use, the general characteristics and habits of the critical group (e.g., an adult light industry worker) and the possible

pathways which describe how the residual radioactivity would incur dose in humans. The licensee should provide justification on the scenario(s) evaluated.

~~The default~~The licensee should justify the possible land use(s) the site might experience in the future and create exposure scenarios consistent with these uses. The licensee should provide justification for selecting the compliance scenario from the possible exposure scenarios derived from the land use. The compliance scenario should result in the greatest exposure to the average member of the critical group for all scenarios given the mixture of radionuclides. A licensee may choose to make a bounding assumption for land use to derive the scenario (e.g., assuming a rural land use for an urban location) or base the scenario on the reasonably foreseeable land use that results in the highest dose.

If the compliance scenario is based on the reasonably foreseeable land use, the licensee should provide justification for the scenario, based on discussions with land planners, meetings with local stakeholders, trending analysis of land use for the region, or comparisons with land use in similar alternate locations. The time period of interest for possible land use is changes within 100 years, depending on the rate of change in the region, and the peak exposure time. The licensee should identify what land uses are unlikely but plausible, and evaluate scenarios consistent with these unlikely land uses. In some cases, the use of reasonably foreseeable land use may require the licensee to evaluate off-site uses of residual radioactivity as alternate scenarios in defining the compliance scenario.

The licensee needs to provide either a quantitative or qualitative analysis of all scenarios generated from the reasonably foreseeable land uses. The level of detail can vary between scenario and it is expected for the licensee to use simple analyses to limit the number of detailed scenarios. The licensee may use screening or generic analyses to assist in determining the critical scenario for compliance. With a mixture of radionuclides, more than one compliance scenario may need to be used. The peak dose from the compliance scenario(s) should exceed the exposures resulting from other scenarios.

Similarly, the licensee needs to provide either a quantitative or qualitative analysis of all scenarios generated from the unlikely land uses. The results of these analyses will be used by the staff to evaluate the degree of sensitivity of dose to overall scenario assumptions (and the associated parameter assumptions). The reviewer will consider both the magnitude and time of the peak dose from these scenarios. If peak doses from the unlikely land use scenarios are significant, the licensee would need to provide greater assurance that the scenario is unlikely to occur, especially during the period of peak dose.

The screening scenarios for building surface residual radioactivity and soil residual radioactivity are described in NUREG–1549 and NUREG/CR–5512, Volumes 1, 2 and 3. Dose evaluations that use these scenarios (i.e., the licensee changes parameter values or mathematical method but does not change the general scenario) are acceptable, if the

scenario is appropriate for the situation. In DPs where the licensee eliminates certain pathways, with justification, but still maintains the same general scenario category, NRC staff should find the scenario identification to be acceptable. For example, a licensee may eliminate the use of ground water because the near surface aquifer has total dissolved solids of 30,000 mg/L. The licensee still evaluates the impacts from crops grown in the residual radioactivity but irrigation is provided by a noncontaminated source and therefore, the ~~default~~ screening scenario, a residential farmer, is maintained.

~~Under certain situations, the default scenarios will not be appropriate for the site conditions. The licensee should provide justification for alternate scenarios. In evaluating the appropriateness of the overall scenario in these cases, NRC reviewers first should evaluate the appropriateness of the critical group selection and the exposure pathways.~~

2. Critical Group Determination

In general, critical groups that are exposed to multiple exposure pathways result in higher doses than groups with more limited interaction with the residual radioactivity. NUREG–1549 and the NUREG/CR–5512 series, details the critical group assumptions for the ~~default~~ screening scenarios. In DPs where the licensee has used th~~e default~~ screening scenarios, the reviewer should verify that the critical group is the same as listed in NUREG–1549 and the NUREG/CR–5512 series.

~~Possible reasons for changing~~The licensee should provide either qualitative or quantitative justification that the critical group ~~assumptions include (a) the available exposure pathways have changed from those in default scenarios and (b) the default scenario is inappropriate based on assumptions regarding current (and informed consideration of future) land use practices in the area (e.g., a small site in a heavily urbanized area). For situations where the licensee has eliminated or modified certain pathways and wishes to use the default critical group definition, the~~ is the highest exposed group for the assumed land use(s). The selection of the critical group may be dependent on the assumption of the relative mixture of radionuclides and sources of residual radioactivity present at the site. The licensee should justify ~~why the exposure group definition does not change from the default assumptions.~~ its compliance approach in these cases. A similar justification should be provided by the licensee for the critical scenario for unlikely scenarios.

3. Exposure Pathways

The DP should describe the exposure pathways to which the critical group is exposed, except for cases where the licensee is using the ~~default~~ screening scenarios and critical groups without modification. ~~T~~If the licensee has chosen to modify the screening scenario, the changes should be justified~~ for cases where the licensee has modified or eliminated exposure pathways~~. In general, the justification should be based on physical limitations or situations that would not allow individuals to be exposed as described in

the scenario. For other scenarios, the exposure pathways should be consistent with the land use assumptions, exposure group behavior, and physical site conditions.

For example, acceptable justifications for removing the ground water pathway include (a) the near surface ground water is neither potable nor allowed to be used for irrigation; (b) aquifer volume is insufficient to provide the necessary yields; and (c) there is current (and informed consideration of future) land use patterns that would preclude ground water use~~, coupled with relatively short half-life material (e.g., the peak exposures would occur within 100 years and the site is currently in an industrial section of an urban area)~~. Justification of water quality and quantity of the saturated zone should be based on the classification systems used by EPA or the State, as appropriate. In cases where the aquifer is classified as not being a source of drinking water but is considered adequate for stock watering and irrigation, the licensee can eliminate (i.e., does not need to consider) the drinking water pathway (and the fish pathway—depending on the ~~model~~ scenario), but the licensee should still maintain the irrigation and meat/milk pathways, if appropriate for the land use assumptions.

Another example would be a rural site with a relatively small discrete outdoor area of residual radioactivity (compared to the area assumed in the default scenarios). In this situation, it may be appropriate, based on the area of residual radioactivity, that gardening of some vegetables and fruits would still be an assumption, but the area is not large enough to allow one to grow grain or raise animals for meat or milk.

- Conceptual Models

NRC staff should review the adequacy of the conceptual model used by the licensee. For additional guidance on these subjects, refer to Section I.4 from Appendix I of this volume.

The conceptual model should qualitatively describe the following:

1. the relative location and activities of the critical group;
2. both the hydrologic and environmental transport processes important at the site;
3. the dimensions, location and spatial variability of the source term used in the model; and
4. the major assumptions made by the licensee in developing the conceptual model (e.g., recharge of the aquifer is limited to the infiltration through the site's footprint).

The NRC reviewer should verify that the site conditions are adequately addressed in the conceptual model and simplifying assumptions.

- Calculations and Input Parameters

In its review, NRC staff will confirm that the licensee has used a mathematical model that is an adequate representation of the conceptual model and the exposure scenario. For additional guidance on these subjects, refer to Sections I.5 and I.6 from Appendix I of this volume.

1. Execution of DandD Computer Code

   If the licensee has used the DandD computer code in its analysis, NRC staff should verify the following points:

   a. The residual radioactivity is limited to the surface (either building or near surface soil, as appropriate).

   b. The site conceptual model is adequately represented by DandD's inherent conceptual model.

   c. For building surfaces, if the total dose is greater than 10 percent of the dose limit, the licensee has modified the resuspension factor to account for the removable fraction to be present at the time of decommissioning.

   d. For sites eliminating pathways, the licensee has used the appropriate parameters in the DandD code as "switches" to turn off the pathways without unintentionally removing others. For example, to remove the ground water pathways, the licensee should set the drinking water rate, irrigation rate, and pond volume to zero.

   e. For each parameter modified, the licensee has adequately justified the new parameter value or range and has evaluated the effect on other parameters.

   f. For modifications of behavioral parameters, the changes should be based on acceptable changes in the critical group, and the mean values of the behavioral parameters should be used, although use of the ranges is also acceptable.

   g. If the licensee has randomly sampled the parameter ranges in DandD, the licensee has used the "peak of the mean" dose distribution to either calculate the dose or derive the DCGLs.

2. Other Mathematical Methods

   The NRC reviewer should verify the following:

   a. The mathematical method's conceptual model is compatible with the site's conceptual model (e.g., RESRAD v. 6.0 would not be an acceptable mathematical method for sites with building surface residual radioactivity).

   b. For each parameter or parameter set, the licensee has adequately justified the parameter value or range. For modifications of behavioral parameters, the changes should be based on acceptable changes in the critical group, and the mean value (or full range) of the behavior should be used.

   c. For residual radioactivity resulting in alpha decay (e.g., uranium or thorium) and present on building surfaces, NRC staff should review the resuspension factor/rate and the assumptions regarding the degree of removable residual radioactivity. For example, if the licensee has assumed that 10 percent of the residual radioactivity will be removable at the time of unrestricted release, the model's parameters

should either implicitly or explicitly include this assumption (see NUREG/CR–5512, Volume 3, on how it has been done for the DandD code).

d. If the licensee has randomly sampled the parameter ranges, the licensee has used the "peak of the mean" dose distribution to either calculate the dose or derive the DCGLs.

- Uncertainty Analysis

  NRC staff should review the licensee's discussion of the uncertainty resulting from the physical parameter values used in the analysis. The review should focus on the uncertainty analysis for the critical pathways or parameters. NRC reviewers should expect that the degree of uncertainty analysis should depend on the level of complexity of the modeling (e.g., generally qualitative discussions for simple modeling to quantitative for more complex sites). The overall acceptability of the uncertainty analysis should be evaluated on a case by case basis. For additional guidance on these subjects, refer to Section I.7 from Appendix I of this volume.

  If the licensee evaluated scenarios based on reasonably foreseeable land uses, the licensee needs to provide either a quantitative or qualitative analysis of all scenarios generated from the unlikely land uses. The results of these analyses will be used by the staff to evaluate the degree of sensitivity of dose to overall scenario assumptions (and the associated parameter assumptions). The reviewer will consider both the magnitude and time of the peak dose from these scenarios. If peak doses from the unlikely land use scenarios are significant, the licensee would need to provide greater assurance that the scenario is unlikely to occur, especially during the period of peak dose.

- Compliance with Regulatory Criteria

  The licensee's projections of compliance with regulatory criteria are acceptable provided that NRC staff has reasonable assurance of the following:

  1. The licensee has adequately characterized and applied its source term.
  2. The licensee has analyzed the appropriate scenario(s) and that the exposure group(s) adequately represents a critical group.
  3. The mathematical method and parameters used are appropriate for the scenario and parameter uncertainty has been adequately addressed.
  4. For deterministic analyses, the peak annual dose to the average member of the critical group for the appropriate exposure scenario(s) for the option is less than (or equal to) 0.25 mSv (25 mrem), or was used to calculate $DCGL_W$.
  5. For probabilistic analyses, the "peak of the mean" dose distribution to the average member of the critical group for the appropriate exposure scenario(s) for the option is less than (or equal to) 0.25 mSv (25 mrem), or was used to calculate $DCGL_W$.

6. Either one of the following:
   a. The licensee has committed to using a specific scenario, model and set of parameters with the final survey results to show final compliance with the dose limit.
   b. The licensee has committed to using radionuclide-specific DCGLs and will ensure that the total dose from all radionuclides will meet the requirements of Subpart E by using the sum of fractions.

5.3 RESTRICTED RELEASE (DECOMMISSIONING GROUP 6)

The following guidance is for reviewing DPs submitted by licensees from Decommissioning Group 6.

AREAS OF REVIEW

NRC staff should review the information provided in the DP pertaining to the licensee's assessment of the potential doses resulting from exposure to residual radioactivity remaining at the end of the decommissioning process. The findings and conclusions of the review under this section should be used to evaluate the DP's compliance with 10 CFR 20.1403. NRC staff should ensure that, at a minimum, information on the source term, exposure scenario(s), conceptual model(s), numerical analyses (e.g., hand calculations or computer models), and uncertainty have been included. NRC staff should review the abstraction and assumptions regarding the source term, the conceptual model of the site or building as appropriate, the exposure scenario(s), the mathematical method employed, and the parameters used in the analysis and their uncertainty.

The amount of information provided by the licensee and the depth of the reviewer's investigation of that information should depend on the complexity of the case and the amount of site-specific information being used by the licensee. This section has been written for review of the most complex analyses; most analyses should not need in-depth review of all parts of the evaluation criteria.

REVIEW PROCEDURES

Acceptance Review

NRC staff should review the DP to ensure that, at a minimum, the DP contains the information summarized under "Areas of Review," above. NRC staff should review the dose modeling portion of the DP without assessing the technical accuracy or completeness of the information contained therein. The adequacy of the information should be assessed during the detailed technical review. NRC staff should review the DP table of contents and the individual descriptions under "Areas of Review," above, to ensure that the licensee or responsible party has

included this information in the DP and to determine if the level of detail of the information appears to be adequate for NRC staff to perform a detailed technical review.

Safety Evaluation

The material to be reviewed is technical in nature, and NRC staff should review the information provided by the licensee to ensure that the licensee used defensible assumptions and models to calculate the potential dose to the average member of the critical group. NRC staff should also verify that the licensee provided enough information to allow an independent evaluation of the potential dose resulting from the residual radioactivity after license termination and provide reasonable assurance that the decommissioning option will comply with regulations.

ACCEPTANCE CRITERIA

Regulatory Requirements

10 CFR 20.1403

Regulatory Guidance

- Appendix I of this NUREG Report
- NUREG–1200, "SRP for the review of a license application for a Low-Level Radioactive Waste Disposal Facility" [sic], Chapter 6
- NUREG–1549, "Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination"
- NUREG–1573, "A Performance Assessment Method for Low-Level Waste Disposal Facilities: Recommendations of NRC's Performance Assessment Working Group"
- NUREG/CR–5512, Volume 1, "Residual Radioactive Contamination from Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent"
- Draft NUREG/CR–5512, Volume 2, "Residual Radioactive Contamination from Decommissioning: User's Manual"
- Draft NUREG/CR–5512, Volume 3, "Residual Radioactive Contamination from Decommissioning: Parameter Analysis"
- Federal Guidance Report Number 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988)
- Federal Guidance Report Number 12, "External Exposure to Radionuclides in Air, Water, and Soil" (EPA 1993)

Information to be Submitted

NRC staff should organize this review by first looking at the overall scope of the dose modeling contained in the DP (possibly for several decommissioning options and/or critical groups). This scoping review, discussed in Chapter 5, should help the reviewers identify which section is applicable for a given dose assessment. After the scoping review, NRC staff should review each of the scenarios that the licensee is using to show compliance with the regulations.

In describing the licensee's dose modeling analysis methods, "site-specific" is used in a very general sense to describe all dose analyses except those based only on the default screening tools. This may be as simple as a few parameter changes, in the DandD computer code from their default ranges, to licensees using scenarios, models, and parameter ranges that are only applicable at the licensee's site. The information submitted should include the following:

- the source term information including nuclides of interest, the configuration of the source, the areal variability of the source, and so forth;
- a description of the exposure scenario including a description of the critical group;
- a description of the conceptual model of the site including the source term, physical features important to modeling the transport pathways, and the critical group;
- the identification, description and justification of the mathematical model used (e.g., hand calculations, DandD v2.1, RESRAD v6.1);
- a description of the parameters used in the analysis;
- a discussion about the effect of uncertainty on the results; and
- input and output files or printouts, if a computer program was used.

This information to be submitted is also included as part of the master DP Checklist provided in this NUREG report (see Section V.c from Appendix D of Volume 1).

EVALUATION CRITERIA

NRC staff should determine the acceptability of the licensee's projections of radiological impacts on the average member of the critical group during the compliance period from residual radioactivity. The information in the DP is acceptable if it is sufficient to ensure a defensible assessment of the possible future impacts from the residual radioactivity. The licensee's assessment can be either realistic or prudently conservative. The information should allow an independent NRC staff evaluation of the assumptions used (e.g., source term configuration, applicable transport pathways) and possible doses to the average member of the critical group.

NRC staff should review the following information, as necessary, for each dose assessment of residual radioactivity that the licensee has submitted in the various decommissioning options.

- Source Term

  NRC staff should review the assumptions used by the licensee to characterize the facility's source term of residual radioactivity for dose modeling purposes. NRC staff should compare the assumptions with the current site information and the decommissioning alternative's goal. The model should be an appropriate generalization of this information. Three key areas of review for the source term assumptions are the (1) configuration, (2) the residual radioactivity spatial variability, and (3) the chemical form(s). For additional guidance, refer to Section I.2 from Appendix I of this volume.

  1. Configuration

     NRC staff should confirm that the actual measurements, facility history, and planned remedial action(s) support the source term configuration used in the modeling by reviewing the information in the facility history, radiological status, and planned remedial action(s) portions of the DP. The NRC reviewer should review the provided information for both the areal extent of residual radioactivity and the depth (for soil or buildings) or volume (for ground water or buried material) of the residual radioactivity. The NRC reviewer should determine if the information provided supports the configuration assumptions used in the exposure scenario and mathematical model (e.g., a thin layer of residual radioactivity on the building surfaces).

  2. Residual Radioactivity Spatial Variability

     NRC staff should review residual radioactivity concentration values provided by the licensee for conditions both before, and projected after, the decommissioning alternative is complete. For this subsection, NRC staff should review the spatial extent and the degree of heterogeneity in the values. Based on this information, NRC staff should determine whether it is reasonable to make an assumption of homogeneity for each source for either (a) the whole site or (b) the specific subsections of the site. NRC staff should then review the adequacy of the licensee's determination of a representative value (or range of values) for the residual radioactivity concentration in the source term model. At the time of the FSS, NRC staff could use, as a general guideline, the concepts related to area factors included in the MARSSIM and in Section I.3.3.3.5 of Appendix I.

     If the licensee develops DCGLs as a result of dose modeling, instead of estimating final concentrations and then, entering them into the code, the licensee need not specifically address the spatial variability acceptance criteria at this time. The licensee should provide information for NRC staff review of the FSS. NRC staff should verify that the spatial variability is compatible with the assumptions made for dose modeling.

3. Chemical Form

The licensee's assumptions regarding the chemical form of the residual radioactivity should be reviewed for its adequacy by NRC staff. NRC staff should determine whether the licensee has considered possible chemical changes that may occur during the time period of interest. Without any justification of possible chemical forms, the analysis should use the bounding chemical form(s) (i.e., the chemical form(s) that give(s) the individual the highest dose per unit intake as described in Federal Guidance Report Number 11). Acceptable rationale for other assumptions should be provided by the licensee. Some acceptable rationales for using other chemical forms are (a) chemical forms that would degrade quickly in the environment (e.g., UF_6) or (b) elements or conditions that are unavailable to realistically form that molecule (e.g., $SrTiO_4$ or high-fired UO_2).

- Critical Groups, Scenarios, and Pathways Identification and Selection

In its review, NRC staff should confirm that the licensee has identified and quantified the most significant scenarios based on available site- or facility-specific information including proposed site restrictions. A minimum of two scenarios will be necessary to evaluate both dose limits. One addresses the situation when the restrictions are in place and working properly. The other addresses the possible doses that may occur if restrictions were to fail. NRC staff should review the basis and justification for the licensee's selected critical group for each scenario. For scenarios in which possible environmental pathways have been modified or eliminated, NRC staff should review the justifications provided by the licensee for those modifications or eliminations. For additional guidance on these subjects, NRC staff is directed to Section I.3 of Appendix I of this volume and Appendix M of Volume 2.

1. Scenario Identification

The compliance exposure scenario~~ is~~ s are based on the location and type of source (e.g., contaminated walls), the reasonably foreseeable land use, the general characteristics and habits of the critical group (e.g., an adult ~~light-industry~~light industry worker)~~, and~~ the possible pathways which describe how the residual radioactivity ~~could~~would incur ~~potential doses in humans~~ dose in humans, and the potential limitations on use because of institutional controls. The licensee should provide justification~~ for why each scenario was selected~~.

~~The default~~on the scenario(s) evaluated.

The licensee should justify the possible land use(s) the site might experience in the future and create exposure scenarios consistent with these uses. One compliance scenario will consider the effect of potential institutional controls limiting the potential uses. The other compliance scenario will analyze the impact of the site with no institutional controls. The licensee should provide justification for selecting each of the compliance scenarios from the possible exposure scenarios derived from the land uses. The compliance scenario should result in the greatest exposure for all scenarios for the mixture of radionuclides. A licensee may chose to make a bounding assumption for land use to derive the scenarios

(e.g., assuming a rural land use for an urban location) or base the scenario on the reasonably foreseeable land use that results in the highest dose.

If the compliance scenarios are based on the reasonably foreseeable land use, the licensee should provide justification for the scenarios, based on discussions with land planners, meetings with local stakeholders, trending analysis of land use for the region, or comparisons with land use in similar alternate locations. The time period of interest for possible land use is for land use changes within 100 years, depending on the rate of change in the region, and the peak exposure time. The licensee should identify what land uses are unlikely but plausible, and evaluate scenarios consistent with these unlikely land uses. In some cases, the use of reasonably foreseeable land use, especially those limited by institutional controls, may require the licensee to evaluate off-site uses of residual radioactivity as alternate scenarios in defining the compliance scenario.

The licensee needs to provide either a quantitative or qualitative analysis of all scenarios generated from the reasonably foreseeable land uses. The level of detail can vary between scenarios, and it is expected for the licensee to use simple analyses to limit the number of detailed scenarios. The licensee may use screening or generic analyses to assist in determining the critical scenario for compliance. With a mixture of radionuclides, more than one compliance scenario may need to be used. The compliance scenario(s) should exceed the exposures from other scenarios.

Similarly, the licensee needs to provide either quantitative or qualitative analysis of the all the scenarios generated from the unlikely land uses. The results of these analyses will be used by the staff to evaluate the degree of sensitivity of dose to overall scenario assumptions (and the associated parameter assumptions). The reviewer will consider both the magnitude and time of the peak dose from these scenarios. If peak doses from the unlikely land use scenarios are significant, the licensee would need to provide greater assurance that the scenario is unlikely to occur, especially during the period of peak dose.

The screening scenarios for building surface residual radioactivity and soil residual radioactivity are described in NUREG–1549 and ~~the~~ NUREG/CR–5512~~ series. The scenarios were developed for situations involving unrestricted release~~, Volumes 1, 2 and 3. Dose evaluations that use these scenarios (i.e., the licensee changes parameter values or mathematical method but does not change the general scenario) are acceptable, if the scenario is appropriate for the situation. In DPs where the licensee eliminates certain pathways, with justification,~~ certain pathways~~ but still maintains the same general scenario category, NRC staff should find the scenario identification to be acceptable. For example, a licensee may eliminate the use of ground water because the ~~near-surface~~ near surface aquifer has total dissolved solids of 30,000 mg/L. The licensee still evaluates the impacts from crops grown in the residual radioactivity but irrigation is provided by a noncontaminated source~~,~~ and therefore, the ~~generic~~ screening scenario, a residential farmer, is maintained.

~~Under most scenarios involving the successful use of site restrictions, the default general scenarios should not necessarily be appropriate for the site conditions. The licensee should need to provide justification for alternate scenarios. NRC reviewers may wish to evaluate the appropriateness of the critical group selection and the exposure pathways in these cases before deciding on the appropriateness of the overall scenario.~~

The restrictions at a site may result in the evaluation of an offsite exposure scenario as the compliance scenario. NUREG–1573 and Chapter 6 of NUREG–1200 provide sources to use for additional guidance focused on assessing offsite exposure.

2. Critical Group Determination

The critical group represents a group that could receive the highest dose from the residual radioactivity. In general, critical groups that are exposed to multiple exposure pathways result in higher doses than groups with more limited interaction with the residual radioactivity. NUREG–1549 and the NUREG/CR–5512 series detail the critical group assumptions for the ~~default~~screening scenarios. In instances where the licensee has used the ~~default~~screening scenarios, NRC staff should verify that the critical group is the same as that listed in NUREG–1549 and the NUREG/CR–5512 series. ~~In other cases, the default scenarios should be used as a guide to review the proposed critical group.~~ For example, it may be acceptable to use the ~~default~~screening critical group for contaminated surface soil in offsite exposure scenarios (e.g., a resident farmer using contaminated ground water flowing from the site).

~~Possible reasons for changing~~The licensee should provide either a qualitative or quantitative justification that the critical group ~~assumptions include (a) the available exposure pathways have changed from those in default scenarios, (b) the default scenario is inappropriate based on assumptions regarding current (and informed consideration of future) land use practices in the area (e.g., a small site in a heavily urbanized area), and (c) proposed restrictions. For situations where the licensee has eliminated or modified certain pathways and wishes to use the default critical group definition, the~~is the highest exposed group for the assumed land use(s). Separate critical groups are necessary for the two primary analysis situations: restrictions working and restrictions not in place. The selection of the critical group may be dependent on the assumption of the relative mixture of radionuclides and sources of residual radioactivity present at the site. The licensee should justify ~~why the exposure group definition does not change from the default assumptions~~its compliance approach in these cases. A similar justification should be provided by the licensee for the critical scenario for unlikely scenarios.

3. Exposure Pathways

The DP should describe the exposure pathways to which the critical group is ~~expected to be~~ exposed, except for cases where the licensee ~~or responsible party~~ is using the ~~default~~screening scenarios and critical groups without modification. ~~T~~If the licensee has chosen to modify the screening scenario, the changes should be justified~~ for cases where the licensee has modified or eliminated exposure pathways~~. In general, the justification

should be based on physical limitations or situations that would not allow individuals to be exposed as described in the scenario. For other scenarios, the exposure pathways should be consistent with the land use assumptions, exposure group behavior, and physical site conditions. The licensee may also use proposed restrictions to eliminate or change exposure pathways.

For example, acceptable justifications for removing the ground water pathway based on physical limitations include any of the following: (a) the near surface ground water is neither potable nor allowed to be used for irrigation, (b) aquifer volume is insufficient to provide the necessary yields, (c) there is current (and informed consideration of future) land use patterns that would preclude ground water use~~ coupled with relatively short half-life material (e.g., the peak exposures would occur within 100 years and the site is currently in an industrial section of an urban area)~~, or (d) site restrictions would preclude ground water use. Justification of water quality and quantity of the saturated zone should be based on the classification systems used by EPA or the State, as appropriate.

For cases where the aquifer is classified as not being a source of drinking water, but is adequate for stock watering and irrigation, the licensee can eliminate the drinking water pathway and generally, the fish pathway, depending on the ~~model~~scenario. The licensee, however, should still maintain the irrigation and meat/milk pathways, if consistent with the land use assumptions.

Another example would be a rural site with a relatively small, discrete, outdoor area of residual radioactivity (compared with the area assumed in the ~~default~~screening scenarios). In this situation, it may be appropriate, based on the area of residual radioactivity, that gardening of some vegetables and fruits would still be an assumption, but the area is not large enough to allow one to grow grain, or raise animals for meat or milk.

- Conceptual Models

NRC staff should review the adequacy of the conceptual model(s) used by the licensee for each exposure scenario, as appropriate. For additional guidance on these subjects, refer to Appendix I, Section I.4, of this volume.

The conceptual model should qualitatively describe the following:

1. the relative location and activities of the critical group;
2. both the hydrologic and environmental transport processes important at the site;
3. the dimensions, location and spatial variability of the source term used in the model;
4. major assumptions made by the licensee in developing the conceptual model (e.g., recharge of the aquifer is limited to the infiltration through the site's footprint); and
5. the effects of the site restrictions on transport or exposure pathways.

The NRC license reviewer should verify that the site conditions and effects of site restrictions are adequately addressed in the conceptual model and simplifying assumptions.

- Calculations and Input Parameters

  In its review, NRC staff should confirm that the licensee has used a mathematical model that is an adequate representation of the conceptual model and the exposure scenario. For additional guidance on these subjects, refer to the Sections I.5 and I.6 from Appendix I of this volume.

  1. Execution of DandD Computer Code

     If the licensee has used the DandD computer code in its analysis, NRC staff should verify the following points:

     a. The residual radioactivity is limited to the surface (building or near surface soil, as appropriate).

     b. The site conceptual model is adequately represented by DandD's inherent conceptual model.

     c. For building surfaces, if the total dose is greater than 10 percent of the dose limit, the licensee has modified the resuspension factor to account for the removable fraction to be present at the time of decommissioning.

     d. For sites eliminating pathways, the licensee has used the appropriate parameters in the DandD code as "switches" to turn off the pathways without unintentionally removing others. For example, to remove the ground water pathways, the licensee should set the drinking water rate, irrigation rate, and pond volume to zero.

     e. For each parameter modified, the licensee has adequately justified the new parameter value or range and has evaluated the effect on other parameters.

     f. For modifications of behavioral parameters, the changes should be based on acceptable changes in the critical group, and the mean value of the behavior should be used, although use of the range is also acceptable.

     g. If the licensee has randomly sampled the parameter ranges in DandD, the licensee has used the "peak of the mean" dose distribution to either calculate the dose or derive the DCGLs.

  2. Other Mathematical Methods

     The NRC license reviewer should verify the following:

     a. The mathematical method's conceptual model is compatible with the site's conceptual model (e.g., RESRAD Ver.6.0 would not be an acceptable mathematical method for sites with building surface residual radioactivity).

     b. For each parameter or parameter set, the licensee has adequately justified the parameter value or range. For modifications of behavioral parameters, the changes should be based on acceptable changes in the critical group, and the mean value (or full range) of the behavior should be used.

c. For residual radioactivity resulting in alpha decay (e.g., uranium or thorium) and present on building surfaces, NRC staff should review the resuspension factor/rate and the assumptions regarding the degree of removable residual radioactivity. For example, if the licensee has assumed that 10 percent of the residual radioactivity will be removable at the time of unrestricted release, the model's parameters should either implicitly or explicitly include this assumption (see NUREG/CR–5512, Volume 3, on how it has been done for the DandD code).

d. If the licensee has randomly sampled the parameter ranges, the licensee has used the "peak of the mean" dose distribution to either calculate the dose or derive the DCGLs.

- Uncertainty Analysis

  NRC staff should review the licensee's discussion of the uncertainty resulting from the physical parameter values used in the analysis. The review should focus on the uncertainty analysis for the critical pathways or parameters. NRC license reviewers should expect that the degree of uncertainty analysis will depend on the level of complexity of the modeling (i.e., generally, qualitative discussions should be for simple modeling, and quantitative discussions should be for more complex sites). The overall acceptability of the uncertainty analysis should be evaluated on a case by case basis. For additional guidance on these subjects, refer to Appendix I, Section I.7.

  Similarly, the licensee needs to provide either a quantitative or qualitative analysis of all scenarios generated from the unlikely land uses. The results of these analyses will be used by the staff to evaluate the degree of sensitivity of dose to overall scenario assumptions (and the associated parameter assumptions). The reviewer will consider both the magnitude and time of the peak dose from these scenarios. If peak doses from the unlikely land use scenarios are significant, the licensee would need to provide greater assurance that the scenario is unlikely to occur, especially during the period of peak dose.

- Compliance with Regulatory Criteria

  The licensee's projections of compliance with regulatory criteria are acceptable provided that NRC staff has reasonable assurance of all the following:

  1. The licensee has adequately characterized and applied its source term.
  2. The licensee has analyzed the appropriate scenario(s) and that the exposure group(s) adequately represents a critical group.
  3. The mathematical method and parameters used are appropriate for the scenario and parameter uncertainty has been adequately addressed.
  4. For deterministic analyses, the peak annual dose to the average member of the critical group is in compliance with the 10 CFR 20.1403(b) or 20.1403(e) dose criteria, as appropriate.

5. For probabilistic analyses, the "peak of the mean" dose distribution to the average member of the critical group for the appropriate exposure scenario(s) for the option is in compliance with the 10 CFR 20.1403(b) or 20.1403(e) dose criteria, as appropriate.
6. Either one of the following:
   a. The licensee has committed to using a specific scenario, model and set of parameters with the final survey results to show final compliance with the dose limit.
   b. The licensee has committed to using radionuclide-specific DCGLs and should ensure that the total dose from all radionuclides will meet the requirements of Subpart E by using the sum of fractions.

5.4 RELEASE INVOLVING ALTERNATE CRITERIA (DECOMMISSIONING GROUP 7)

The following guidance is for reviewing DPs submitted by licensees from Decommissioning Group 7.

AREAS OF REVIEW

NRC staff should review the information provided in the DP pertaining to the licensee's proposed alternate criteria. The findings and conclusions of the review under this section should be used to evaluate the DP's compliance with 10 CFR 20.1404. NRC staff should ensure that, at a minimum, information on the source term, exposure scenario(s), conceptual model(s), numerical analyses, and uncertainty have been included, if appropriate. NRC staff should review the abstraction and assumptions regarding the source term, the conceptual model of the site or building as appropriate, the exposure scenarios, the mathematical method employed, and the parameters used in the analyses and their uncertainty. NRC staff should also review the health, safety, and protection of the environment basis for the alternate criteria proposed.

The amount of information provided by the licensee and the extent of NRC staff's review of that information should depend on the complexity of the case and the amount of site-specific information being used by the licensee.

REVIEW PROCEDURES

Acceptance Review

NRC staff should review the DP to ensure that, at a minimum, the DP contains the information summarized in the above "Areas of Review." NRC staff should review the dose modeling portion of the DP without assessing the technical accuracy or completeness of the information contained therein. The adequacy of the information should be assessed during the detailed

technical review. NRC staff should review the DP table of contents and the individual descriptions under the above "Areas of Review" to ensure that the licensee has included this information in the DP and to determine if the level of detail of the information appears to be adequate for NRC staff to perform a detailed technical review. NRC staff should use Section 5.3 of this volume and Chapter 6 of NUREG–1200, "SRP for the review of a license application for a Low-Level Radioactive Waste Disposal Facility" [sic], as guidelines, in developing site-specific acceptance review criteria for the proposed alternate criteria and the licensee's compliance evaluation.

Safety Evaluation

The material to be reviewed is technical in nature, and NRC staff should review the information provided by the licensee to ensure that the licensee used defensible assumptions and models to establish and demonstrate compliance with the proposed alternate criteria. NRC staff should also verify that the licensee provided enough information to allow an independent evaluation of the assessment resulting from the residual radioactivity after license termination and provide reasonable assurance that the decommissioning option should comply with regulations. Each evaluation should be performed on a case-by-case basis. NRC staff should use Section 5.3 of this volume and Chapter 6 of NUREG–1200, as guidelines, in developing site-specific review criteria for the proposed alternate criteria and the licensee's compliance evaluation.

An alternative release proposal in accordance with 10 CFR 20.1404 may allow a dose of up to 1.0 mSv/y (100 mrem/y) with restrictions in place. However, if the restrictions fail, the dose may not exceed the values in 10 CFR 20.1403(e). Furthermore, all of the other provisions of 10 CFR 20.1403 must be met.

Changes to NUREG-1757, Vol. 2, Appendix I, Section I.3, "Criteria for Selecting and Modifying Scenarios, Pathways, and Critical Groups"

I.3 Criteria for Selecting and Modifying Scenarios, Pathways, and Critical Groups

This information was taken from NUREG–1727, Appendix C, Section 4. The section has been revised, appropriately, to remove redundancy, use consistent terminology in this document, and expand the discussion on area factors (Section I.3.3.3.5 of this appendix) but the essential information is the same.

I.3.1 Introduction

After the source term has been evaluated, the question becomes: "How could humans be exposed either directly or indirectly to residual radioactivity?" or "What is the appropriate exposure scenario?" Each exposure scenario should address the following questions:

1. How does the residual radioactivity move through the environment?
2. Where can humans be exposed to the environmental concentrations?
3. What is the likely land use(s) in the future for these areas?
4. What are the exposure group's habits that will determine exposure? (e.g., what do they eat and where does it come from? How much? Where do they get water and how much? How much time do they spend on various activities? etc.)

The ultimate goal of dose modeling is to estimate the dose to a specific receptor. Broad generalizations of the direct or indirect interaction of the affected receptors with the residual radioactivity can be identified for ease of discussion between the licensee, regulator, public, and other interested parties. Scenarios are defined as reasonable sets of human activities related to the future use of the site. Therefore, scenarios provide a description of future land uses, human activities, and behavior of the natural system.

In most situations, there are numerous possible scenarios of how future human exposure groups could interact with residual radioactivity. The compliance criteria in Part 20 for decommissioning does not require an investigation of all (or many) possible scenarios; its focus is on the dose to members of the critical group. The critical group is defined (at 10 CFR 20.1003) as "…the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

By combining knowledge about the answers to Questions 1 and 2, the licensee can develop exposure pathways. Exposure pathways are the routes that residual radioactivity travels, through the environment, from its source, until it interacts with a human. They can be fairly simple (e.g., surface-soil residual radioactivity emits gamma radiation, which results in direct exposure to the individual standing on the soil) or they can be fairly involved (e.g., the residual radioactivity in the surface soil leaches through the unsaturated soil layers into the underlying

aquifer and the water from the aquifer is pumped out by the exposed individual for use as drinking water, which results in the exposed individual ingesting the environmental concentrations). Exposure pathways typically fall into three principal categories, identified by the manner in which the exposed individual interacts with the environmental concentrations resulting from the residual radioactivity: ingestion, inhalation, or external (i.e., direct) exposure pathways.

As required under Subpart E, the dose from residual radioactivity is evaluated for the average member of the critical group, which is not necessarily the same as the maximally exposed individual. This is not a reduction in the level of protection provided to the public, but an attempt to emphasize the uncertainty and assumptions needed in calculating potential future doses, while limiting boundless speculation on possible future exposure scenarios. Although it is possible to actually identify with confidence the most exposed member of the public in some operational situations (through monitoring, time studies, distance from the facility, etc.), identification of the specific individual who may receive the highest dose some time (up to 1000 years) in the future is impractical, if not impossible. Speculation on his or her habits, characteristics, age, or metabolism could be endless. The use of the "average member of the critical group" acknowledges that any hypothetical "individual" used in the performance assessment is based, in some manner, on the statistical results from data sets (e.g., the breathing rate is based on the range of possible breathing rates) gathered from groups of individuals. Although bounding assumptions could be used to select values for each of the parameters (i.e., the maximum amount of meat, milk, vegetables, possible exposure time, etc.), the result could be an extremely conservative calculation of an unrealistic scenario and may lead to excessively low allowable residual radioactivity levels, compared to the actual risk.

Calculating the dose to the critical group is intended to bound the individual dose to other possible exposure groups because the critical group is a relatively small group of individuals, because of their habits, actions, and characteristics, who could receive among the highest potential dose at some time in the future. By using the hypothetical critical group as the dose receptor, coupled with prudently conservative models, it is highly unlikely that any individual would actually receive doses in excess of that calculated for the average member of the critical group. The description of a critical group's habits, actions, and characteristics should be based on credible assumptions and the information or data ranges used to support the assumptions should be limited in scope to reduce the possibility of adding members of less exposed groups to the critical group.

ALARA analyses should use the dose based on the reasonably foreseeable land use for any cost-benefit calculations performed.

I.3.2 Issues in Selecting and Modifying Scenarios, Pathways, and Critical Groups

The definition of scenarios, identification of a critical group with its associated exposure pathways, and the dose assessment based on that definition can be generic or site specific. Licensees might:

- Use screening scenarios, screening groups, and pathway parameters as described in NUREG–1549 (NRC 1998a) and the NUREG/CR–5512 series. This can be used for either screening or site-specific analyses.
- Use the default screening scenarios as a starting point to develop more site-specific pathway analyses or critical group habits.
- Develop site-specific scenarios, critical groups, and identify associated exposure pathways from scratch.

To establish either site-specific scenarios, critical groups, and/or sets of exposure pathways, the licensee may need to provide justifications defending its selections. For some licensees, this may require minimum amounts of site-specific data to support the assumptions inherent in the existing default screening scenarios or for removing specific exposure pathways. For others, the licensee may need to thoroughly investigate and justify the appropriateness of the selected scenarios and/or critical groups, which may include evaluation of alternate scenarios and/or critical groups. If a licensee creates the exposure scenario and associated critical group based on site-specific conditions (e.g., at a site that is grossly different than the assumptions inherent in the default scenarios), the licensee should provide documentation that provides a transparent and traceable audit trail for each of the assumptions used in developing the exposure scenario and critical group [e.g., justify the inclusion (or exclusion) of a particular exposure pathway].

I.3.3 Recommended Approaches

I.3.3.1 Screening Analyses

In the case of screening, the decisions involved in identifying the appropriate scenario and critical group, with their corresponding exposure pathways, have already been made. Scenario descriptions acceptable to NRC staff for use in generic screening are developed and contained in NUREG/CR–5512, Volume 1. NUREG/CR–5512, Volume 3, and NUREG–1549, 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); and the associated parameter values or ranges (only from NUREG/CR–5512, Volume 3). A summary of the scenarios is in Table I.2. The latest version of the DandD computer code should contain the latest default data values for the critical group's habits and characteristics.

Table I.2 Pathways for Generic Scenarios

Building Occupancy Scenario This scenario accounts for exposure to fixed and removable residual radioactivity on the walls, floor, and ceiling of a decommissioned facility. It assumes that the building may be used for commercial or light industrial activities (e.g., an office building or warehouse). Pathways include: • external exposure from building surfaces; • inhalation of (re)suspended removable residual radioactivity; and • inadvertent ingestion of removable residual radioactivity.
Resident Farmer Scenario This scenario accounts for exposure involving residual radioactivity that is initially in the surficial soil. A farmer moves onto the site and grows some of his or her diet and uses water tapped from the aquifer under the site. Pathways include: • external exposure from soil; • inhalation to (re)suspended soil; • ingestion of soil; • ingestion of drinking water from aquifer; • ingestion of plant products grown in contaminated soil and using aquifer to supply irrigation needs; • ingestion of animal products grown onsite (using feed and water derived from potentially contaminated sources); and • ingestion of fish from a pond filled with water from the aquifer.

I.3.3.2 Site-Specific Analyses

Site-specific analyses give licensees greater flexibility in developing the compliance scenario. The licensee should justify its selection of the compliance scenario based on reasonably foreseeable land use at the site. The compliance scenario should result in an exposure to the public, such that no other scenario, using reasonably foreseeable land use assumptions, will result in higher doses to its exposure group(s). The level of justification and analysis provided by the licensee will be depend on the how close the analysis is to the “real” dose. The more realistic the

analysis, greater degrees of justification and, potentially ancillary analyses, will be required. For example, a site is currently zoned industrial and the local area is a mix of suburban, commercial, and industrial. Rural uses of the property are unlikely for the foreseeable future. If the licensee chose to use the generic screening scenario, the licensee would need to provide limited justification for the bounding scenario. If the licensee proposed to use a maintenance worker scenario assuming industrial land use as the compliance scenario, the licensee would need to provide quantitative or qualitative analyses of other competing scenarios (based on industrial land use and on suburban or commercial land use) to justify the selection of the compliance scenario. In addition, the licensee would need to provide analyses of the rural use of the land to show what impacts would occur from this unlikely situation.

Site-specific analyses can use the generic screening scenario(s) with a little justification. The licensee may need to justify that the site contains no physical features nor locations of residual radioactivity, other than those assumed in the screening analyses, that would invalidate the assumptions made in developing the scenarios. The NRC license reviewer should evaluate the justification to provide reasonable assurance that the generic scenario would still be appropriate for the site. A site can fail to meet the requirements of the conceptual model (see Section I.4 of this appendix) without invalidating the generic scenario, and situations can arise where the default scenario is no longer the limiting case. For example, the site may have pre-existing ground water contamination, which is counter to the assumptions in the conceptual model inherent in the screening models, but this may not require any change in the exposure scenario because the residential farmer scenario may still be an appropriate scenario, as it contains all of the appropriate exposure pathways, including ground water use for drinking, irrigation, and for animals. Alternately, if the residual radioactivity were a volumetric source in the walls of a building, rather than on the building surfaces, the generic exposure scenario of an office worker may not be the scenario leading to the critical group. For certain sets of radionuclides, a building renovation scenario may be more limiting because of the exposure to airborne concentration of material as the walls are modified.

Site-specific scenarios, critical groups, and pathways can be developed, for any situation, and would occur in cases where, for example:

1. Major pathways (e.g., the ground water pathway, or agricultural pathways) associated with the default screening scenarios could be eliminated, either because of physical reasons or site-use reasons.
2. The location of the residual radioactivity and the physical features of the site are outside the major assumptions used in defining the default critical group and/or scenarios.
3. Restricted use was proposed for a site.

The second situation listed above can be ambiguous, as a number of assumptions key to the development of the DandD screening tool do not affect the scenario description, and may require an NRC reviewer to evaluate whether the initial generic scenario would still be appropriate for the site.

Modifying scenarios or developing a site-specific critical group requires information regarding plausible uses of the site and demographic information. Such information might include considerations of the prevailing (and future) uses of the land, and physical characteristics of the site that may constrain site use. Land use considerations should characterize potential land use into one of three categories: reasonably foreseeable, unlikely, and implausible. Any land uses that similar property in the region currently has, or may have in the near future (e.g., less than 100 years), should be characterized as reasonably foreseeable. Consideration should be given to trends and area land use plans in determining the likelihood of potential land use. Land uses that are plausible, generally because similar land historically was used for the purpose, but are counter to the current trends or regional experience could be characterized as unlikely (e.g., rural use of property currently in an urban setting). Implausible land uses are those that because of physical limitations could not occur (e.g., residential land use for an underwater plot of land). It may be necessary to evaluate several potential critical groups, based on different combinations of site-specific scenarios developed from expected land use, pathways and demographics, to determine the group receiving the highest exposure.

Depending on the resulting exposure scenarios, considerations of off-site exposure by either transport (e.g., through ground water) or material transfer (e.g., soil being taken from the site and used elsewhere) may be necessary to identify the critical group. Thus, the licensee should consider if off-site uses are reasonably foreseeable. If they are, such off-site uses should also be analyzed to determine if the critical group might be an off-site user instead of an onsite user.

Similar considerations apply for restricted release. Thus, when analyzing the dose under restricted conditions, the nature of the critical group is likely to change because of these restrictions and controls. Site restrictions and institutional controls can restrict certain kinds of activities and land or water uses associated with the physical features of the site. The detailed definition of the scenarios considered for restricted release need to include the impact of the control provisions on the location and behavior of the average member of the appropriate critical group. Restricted-release license-termination or DPs must also evaluate the impact if the restrictions were to fail. This may require the licensee to explore different "failure" exposure scenarios, including partial failure of engineered features of the site (e.g., engineered covers, subsurface engineered features whose partial failure may result in focused flow) and, more commonly, use of the site assuming a situation similar to unrestricted release.

The NRC license reviewer should evaluate the justifications provided by the licensee on its scenarios using the following appropriate guidance. The guidance is characterized by the general approach used in development of the scenarios: (a) modifying existing generic exposure scenarios or (b) developing site-specific scenarios from "scratch."

I.3.3.2.1 Modification of Generic Scenarios

First, the NRC license reviewer should evaluate whether the generic scenario was applicable to the site before modification. If the scenario was applicable before the licensee started modifying the scenario based on physical features or restrictions, go to the next step and evaluate the justifications for the various modifications performed by the licensee. If the scenario was not initially applicable, that does not mean that a final modified scenario is inappropriate for the site conditions. It just means that the review may be more complex than a simple modification of a scenario and that the NRC license reviewer should evaluate whether it may be more appropriate to evaluate the scenario using the guidance below.

The NRC license reviewer should identify the modifications done by the licensee to the scenario and evaluate the licensee's justification for those changes. Table I.3 lists some common exposure scenarios, but is by no means comprehensive. The Sandia Letter Report, "Process for Developing Alternate Scenarios at NRC Sites Involved in D&D and License Termination" (Thomas, et al., 2000), which is included in this volume as Appendix M, provides a series of flow charts and sources of information to assist a licensee or reviewer in modifying the default scenarios using site-specific information. See below for specific guidance on acceptable justifications using different types of site-specific information, which was adapted from the letter report. Additionally, if the licensee's intent is restricted release, the final scenario should be reviewed looking at the effect of site restrictions. The licensee's justifications should support, based on either site restrictions or site-specific data, the elimination of scenarios and pathways from the analysis. The NRC license reviewer should focus the review on the pathways, and models associated with those pathways, that have the highest likelihood of significant exposures to the critical group.

Table I.3 Potential Scenarios for Use in Dose Assessments

General Scenario Classification
• Building occupancy (Generic screening – NUREG/CR–5512-based).
• Residential farmer (Generic screening – NUREG/CR–5512-based).
• Urban construction (contaminated soil, no suburban or agricultural uses). This scenario is meant for small urban sites cleared of all original buildings; only contaminated land and/or buried waste remains.
• Residential (a more restricted subset of the residential farmer scenario, for those urban or suburban sites where farming is not a realistic projected future use of the site).
• Recreational User (where the site is preserved for recreational uses only).
• Maintenance Worker (tied to the Recreational User scenario but involves the grounds keepers maintaining or building on the site).
• Hybrid industrial building occupancy (adds contaminated soil, building may or may not be contaminated).
• Drinking water (e.g., no onsite use of ground water; offsite impacts from the contaminated plume).

The licensee may need to evaluate whether the final modified scenario is still the limiting reasonable representation of the critical group at the site. This may involve investigation of exposure pathways not covered in the default scenarios.

I.3.3.2.2 Development of Alternate Scenarios

In some decommissioning cases, either the location of the residual radioactivity, the physical characteristics of the site, and/or planned institutional restrictions may make the default scenarios inappropriate. In other cases, the licensee may wish to provide a transparent and traceable development of the compliance and other exposure scenarios, starting with the potential land use and the site conditions. Development (and review) of alternate scenarios may involve iterative steps involving the development of the conceptual model of the site. For example, the licensee may (a) develop a generic list of exposure pathways, (b) develop the site conceptual model to screen the generic list, (c) aggregate or reduce the remaining exposure pathways to the major exposure pathways, and (d) re-evaluate the conceptual model to verify that all the necessary processes are included.

A brief summary of the NRC–recommended pathway analysis process follows. An example development of exposure scenarios, while developed for partial site release, is listed in Appendix K.

- The licensee compiles a list of exposure pathways applicable to any contaminated site. There are a number of existing sources of information that can be used. One source is NUREG/CR–5512, Volume 1 (NRC 1992), and the list is summarized in Appendix C.1 of NUREG–1549 (NRC 1998a). Another source, although the guidance is more focused on offsite exposures, is NUREG/CR–5453, Volumes 1 and 2, "Background Information for the Development of a Low-Level Waste Performance Assessment Methodology" (Shipers 1989; Shipers and Harlan 1989). Another potential source is the international "Features, Events and Processes," list which is an expansive generic list that does not strictly deal with decommissioning issues (SSI 1996).
- Categorize the general types of residual radioactivity at the site (e.g., sediment or soil, deposits in buildings, surface residual radioactivity, surface water, ground water, industrial products such as slag).
- Screen out pathways, for each contaminant type, that do not apply to the site.
- Identify the physical processes pertinent to the remaining pathways for the site.
- Separate the list of exposure pathways into unique pairs of exposure media (e.g., source to ground water, ground water to surface water, etc.). Determine the physical processes that are relevant for each exposure media pair and combine the processes with the pathway links.
- Reassemble exposure pathways for each source type, using the exposure media pairs as building blocks, thus associating all the physical processes identified with the individual pairs with the complete pathway.

The licensee's documentation of the decisions made regarding inclusion (or exclusion) of the various pathways should be transparent and traceable. An international working group of Biospheric Model Validation Study, Phase II (SSI 1996) established a methodology for developing models to analyze radionuclide behavior in the biosphere and associated radiological exposure pathways (i.e., the Reference Biospheres Methodology). BIOMOVS II published the methodology in its Technical Report No.6, "Development of a Reference Biospheres Methodology for Radioactive Waste Disposal" (SSI 1996), and it may be useful as a guide for additional information on a logical method to complete the pathway analysis sets above and include proper justification. Generally, the Reference Biospheres Methodology is more useful for complex sites that may have numerous physical processes that interact in such as a way that a number of different exposure groups may need to be investigated to discover the critical group. Additional work has been done on implementing the Reference Biospheres Methodology by a working group of the International Atomic Energy Agency's Biosphere Modeling and Assessment (BIOMASS) program (IAEA 1999a). Specifically, IAEA Working Document BIOMASS/T1/WD03, "Guidance on the Definition of Critical and Other Hypothetical Exposed Groups for Solid Radioactive Waste Disposal," may provide additional information on developing a site-specific critical group for situations where the generic critical group is inappropriate.

I.3.3.3 Guidance on Specific Issues

I.3.3.3.1 Land Use

A licensee's assumptions for land use should focus on current practice in the region. The region of concern can be as large as an 80-kilometer (50-mile) radius. To narrow the focus of current land practices, the licensees can use information on how land use has been changing in the region, and more weight should be given to land-use practices either close to the site or in similar physical settings. This can be very important for semi-rural sites that are being encroached by suburban residential development. Reviewers may wish to involve State and local land-use planning agencies in discussions, if the licensee has not already requested their involvement.

Land use considerations should characterize potential land use into one of three categories: reasonably foreseeable, unlikely, and implausible. Any land uses that similar property in the region currently has, or may have in the near future (e.g., less than 100 years), should be characterized as reasonably foreseeable. Consideration should be given to trends and area land use plans in determining the likelihood of potential land use. The time frame of interest will depend on such factors as the rate of change in land use patterns in the area, radionuclides of interest and the time of peak dose.

Land uses that are plausible, generally because similar land historically was used for the purpose, but are counter to the current trends or regional experience should be characterized as unlikely (e.g., rural use of property currently in an urban setting).

Implausible land uses are those that because of generally physical limitations could not occur (e.g., residential land use for an underwater plot of land).

Land use arguments by licensees often rely on State or local codes, in building or well development to constrain future use. In general, licensees looking for unrestricted release should not rely solely on these arguments as reason to remove pathways or justify the scenario unless (a) the radionuclides have a relatively short-half life (approximately 10 years or less) or (b) the dose from long-lived radionuclides reaches its peak before 100 years. Similarly, licensees requesting unrestricted release should not limit land use scenarios based on commitments, or require the enforcement, of limitations by the licensee or another party (e.g., a licensee states that the land will remain industrial because the licensee states that the land will not be sold by the licensee after the license is terminated).

Licensees should base justifications of land use on (1) the nature of the land and reasonable predictions based on its physical and geologic characteristics, and (2) societal uses of the land based on past historical information, current uses of it and similar properties, and what is reasonably foreseeable in the near future. The societal uses of the site in the future should be based on advice from local land planners and other stakeholders on what possible land uses are likely within a time period of the next few decades to around a hundred years. The level of

justification for the final land uses is inversely proportional to the level of realism assumed by the licensee. Limited justification may be required for bounding analyses while much more detailed justification including alternate reasonably foreseeable and unlikely scenario analyses may be needed for a situation with a smaller degree of conservatism in the analyses.

Additional guidance is available on potential sources of land use information in Appendix M.5.

I.3.3.3.2 Waterborne Exposure Pathways

Removal of waterborne exposure pathways can range from being global (e.g., all ground water pathways) to being specific (e.g., no drinking water but still have agricultural/fish pond use). Acceptable justifications are generally based on physical conditions at the site rather than local codes. Justification of water quality and quantity of the saturated zone should be based on the classification systems used by the U.S. Environmental Protection Agency (EPA) or the State, as appropriate. Arguments involving depth to water table, or well production capacity, should have supporting documentation from either the U.S. Geological Survey (USGS), appropriate State agency, or an independent consultant.

NRC license reviewers should evaluate the reasons for the classification. Tables M.5–M.12 in Appendix M provide details regarding water quality standards. For example, where the aquifer is classified as not being a source of drinking water, but is adequate for stock watering and irrigation, the licensee can eliminate the drinking water pathway, but should still maintain the irrigation and meat/milk pathways. Aquifers may exceed certain constituents and still be able to be used for various purposes because those constituents may easily be treatable (e.g., turbidity). In cases where the water may be treatable or because the degree of connection between the aquifer and surface water may make the use of the aquifer questionable, the NRC license reviewer should involve the EPA and/or the State, as appropriate, in discussions on reasonable assumptions for the aquifer use.

I.3.3.3.3 Agricultural Pathways

Agricultural pathways may be removed or modified for various reasons: (a) land use patterns, (b) poor-quality soil, (c) topography, and (d) size of contaminated area. Many justifications may result in modification of the pathways, rather than complete elimination. For example, the soil may of inappropriate quality to support intensive farming activities, but residential gardening may still be reasonable.

Licensees using poor-quality soil as a justification for modifying the agricultural pathways should provide the reviewer with supporting documentation from the Soil Conservation Service, appropriate State or local agency, or an independent consultant. Reviewers should carefully consider whether the state of the soil would reasonably preclude all activities (e.g., because of high salinity of soil) or only certain activities. In most cases, soil quality can reasonably preclude activities such as intensive farming, but could allow grazing or small gardens.

When reviewing justifications involving topography, the NRC license reviewer should limit speculation of future topographical changes from civil engineering projects. The NRC license reviewer should evaluate the reasonableness of the critical group performing its activities on the current topography, for example, a slope. Supporting documentation should be provided by the licensee in the form of pictures, USGS or similar topographic maps, hand-drawn maps, or a detailed description of how the topography would limit farming. NRC reviewers may wish to perform a site visit to evaluate the topography firsthand.

I.3.3.3.4 Age-Dependent Critical Groups

Use the definitions in Part 20 when calculating for compliance with the requirements of Subpart E. Use the Federal Guidance Report No. 11 when calculating internal exposures by using the intake-to-dose conversion factors, which are based primarily on adults. As stated in the Environmental Protection Agency's *Federal Register* notice (59 FR 66414, Dec. 23, 1994) on "Federal Radiation Protection Draft Guidance for Exposure of the General Public," which proposes a public dose limit of 1.0 mSv/y (100 mrem/y) from all sources:

> "These dose conversion factors are appropriate for application to any population adequately characterized by the set of values for physiological parameters developed by the [International Committee on Radiological Protection] and collectively known as "Reference Man." The actual dose to a particular individual from a given intake is dependent upon age and sex, as well as other characteristics. As noted earlier, implementing limits for the general public expressed as age and sex dependent would be difficult.... More importantly, the variability in dose due to these factors is comparable in magnitude to the uncertainty in our estimates of the risks which provide the basis for our choice of the [public dose limit]. For this reason EPA believes that, for the purpose of providing radiation protection under the conditions addressed by these recommendations, the assumptions exemplified by Reference Man adequately characterize the general public, and a detailed consideration of age and sex is not generally necessary." (59 FR 66423, Dec. 23, 1994) [sic]

Since age-based dose conversion factors are not being used, the same dose conversion factors are applied to all individuals. Only in rare scenarios will a non-adult individual receive a higher dose (i.e., intake more radioactive material) than an adult individual in a similar exposure scenario. One example is the milk pathway, children generally drink more milk annually than adults. If milk was the only pathway that would expose the individual to a dose, then the child would have a slightly higher dose than the adult. But in most situations, especially ones involving multiple pathways, the total intake of the adult is greater than that of a child. Therefore, for most multiple pathway scenarios, such as screening analyses, the average member of the critical group should usually be assumed to be an adult, with the proper habits and characteristics of an adult. As the licensee eliminates pathways or modifies the scenario, the behavior and dietary habits of children may become important. In such cases, the licensees should consult with NRC staff for guidance.

I.3.3.3.5 Area Factors

The $DCGL_W$ is the average concentration across the site that is calculated to result in the average member of the critical group receiving a dose at the appropriate dose limit [e.g., 0.25 mSv/y (25 mrem/y) for unrestricted release]. The general assumption is that the concentration of the radionuclides in the source are fairly homogenous. The degree to which any single localized area can be elevated above the average, assuming the average is at the $DCGL_W$, and not invalidate the homogenous assumption is characterized by the $DCGL_{EMC}$ (see Chapter 4 of this volume and MARSSIM). One method for determining values for the $DCGL_{EMC}$ is to modify the $DCGL_W$ using a correction factor that accounts for the difference in area and the resulting change in dose. The area factor is then the magnitude by which the concentration within the small area of elevated activity can exceed $DCGL_W$ while maintaining compliance with the release criterion.

The area factor works by taking into consideration how a smaller area would affect the dose to the average member of the critical group. For example, a smaller area could mean that external dose is more limited because it is not reasonable to expect the individual to be exposed the same amount of time as the individual would be to a larger area.

The default scenario for surface soil assumes large areas of homogeneous surface residual radioactivity. If the area of residual radioactivity is smaller than the defaults [e.g., 2400 m^2 (0.6 ac) for DandD], the licensee may propose modifying the exposure pathways to account for the effect on the critical group's activities. The licensee can follow either of two methods:

- Reduce the calculated dose by modifying the exposure time or usage parameters accordingly.
- Modify the exposure scenario and pathways and/or modify the calculational method to account for the size of the residual radioactivity.

These methods are built into both the DandD and RESRAD codes for surficial soil. When the user changes the size of the contaminated area, the code will modify the appropriate usage factors and remove pathways if they are no longer viable.

When the extent of residual radioactivity becomes smaller, some of the activities are no longer viable as reasonable assumptions for exposure. Generally, the first pathways affected are animal husbandry activities, because of the larger area needs for grazing and growing fodder. As a general rule, as the area gets smaller, the more the scenario transforms into a residential gardener scenario, so long as the initial residual radioactivity begins in the surface soil. For cases where the residual radioactivity is not in the surficial soil, the original area of residual radioactivity may not be as important in scenario development, because some of the primary transport mechanisms result in redistribution of the radionuclides over larger areas (i.e., ground water used as irrigation).

One common mistake in licensee submittals is that area factors are typically not provided for residual radioactivity on building surfaces. The primary reason for this is that such factors could not be calculated by using the DandD, Version 1. Therefore, when the screening $DCGL_W$ values were published in the *Federal Register* (see Appendix H), which were derived from an improved DandD, Version 1, the associated area factors were not published. An alternative approach should be used to calculate area factors for residual radioactivity on building surfaces.

One approach is to use DandD, Version 2.1, to calculate the area factors, although it models area factors conservatively. Another approach that has been successfully used is to develop the area factors by using the RESRAD–BUILD computer code and adjusting these derived area factors to account for the fact that RESRAD–BUILD typically gives less conservative dose estimates. With this approach, the screening DCGL values are converted into the appropriate concentration unit for RESRAD–BUILD [i.e., from (dpm per 100 cm^2) to (pCi/m^2)]. Area factors calculated by RESRAD–BUILD can then be adjusted by the ratio of the dose from RESRAD–BUILD to 0.25 mSv/y (25 mrem/y) (i.e., the equivalent dose from DandD).

I.3.3.3.6 Offsite Scenarios

In rare situations, the scenario resulting in the highest exposures from the residual radioactivity will be offsite use scenarios. In these scenarios, the exposure to the radioactivity material will occur because it has been removed from the current location for some reason and this results in either new or enhanced exposure pathways. For example, a site has poor ground water characteristics (thereby, allowing the licensee to remove the ground water pathway from any applicable scenarios) and the reasonably foreseeable land use is either commercial or industrial. The primary contaminant is Tc-99, which primarily results in dose through either the ground water or vegetable pathways, both of which are not applicable to the physical characteristics of the site or land use assumptions. The residual radioactivity is present in the site's top soil. A possible offsite scenario is that during construction of any commercial interest on the site after license termination, the removed topsoil is sold for use in a residential setting. In this case, it is likely that the topsoil with residual radioactivity will be unintentionally mixed with other topsoil at the offsite location. Licensees can use generic analyses to screen the importance of off site uses with such sources as NUREG-1640, "Radiological Assessments for Clearance of Materials from Nuclear Facilities." (NRC 2003)

Even if off-site use is not considered reasonably foreseeable, off-site scenarios may be plausible unlikely scenarios, and should be analyzed as alternate and less likely scenarios, to understand the robustness of the analysis.

I.3.3.3.7 Determining the Compliance Scenario

In many situations a licensee will be faced with selecting a compliance scenario from potentially a large suite of scenarios and exposure groups. The licensee is expected to base their demonstration of compliance on the exposure to the highest group, consistent with the definition

of the critical group. Licensees may find it advantageous to use an iterative approach to screen all the potential scenarios. This will allow the licensees to focus their more detailed analyses on the important scenarios. Licensees may be able to use information from NUREG/CR-5512, NUREG-1640, and NUREG-1717, as well as other licensees' analyses to screen their potential scenarios with quantitative methods. Licensees also may be able to provide qualitative arguments to demonstrate that the dose from certain scenarios are bounded by the dose of higher level scenarios (e.g., a residential gardening scenario will bound the dose for the residential non-gardening scenario). The licensees should provide justifications on the basis, method, and results of their scenario screening in their DP.

Even after screening the scenarios, a licensee will likely be left with a few scenarios that may require detailed analyses to determine which will result in the critical group. For licensees with multiple radionuclides, commonly, determining the compliance scenario depends on the final mixture of radionuclides. This can provide a dilemma for licensees creating DCGLs. The licensee must show that the final concentrations at the site meet the dose criteria of 10 CFR Part 20, Subpart E. Three possible approaches that the licensee may use to show compliance are, but are not limited to the following:

1. Use the most limiting DCGL for each radionuclide, regardless of the scenario, and use the sum of fractions, ignoring the scenario basis for each DCGL. This approach requires limited justification. It will always either estimate the same dose as the individual scenarios or overestimate the dose. Generally, it will greatly overestimate the dose for the individual scenarios.

2. Use a surrogate approach to limit the number of radionuclides of importance. A surrogate approach relies on different radionuclides having relatively fixed ratios. For example, assume that at a site with cesium-137 and strontium-90 can show that for every 37 Bq/kg (1 pCi/g) of Cs-137, there will be a 18 Bq/kg (0.5 pCi/g) of Sr-90. By using this relationship, an effective DCGL for combined Cs-137 and Sr-90 can be created. The licensee may be able to reduce the number of critical scenarios, specifically those driven by exposure to Sr-90. This approach requires that the licensee have all the necessary information on relative ratios of the radionuclides.

3. Commit to demonstrating the final dose for each of the important scenarios in the final status survey reports. This approach will require the licensee to establish operational DCGLs to fully utilize MARSSIM (see Section 2.5).

The licensee needs to provide either quantitative or qualitative analysis of all the scenarios generated from the unlikely land uses. The results of these analyses will be used by the staff to evaluate the degree of sensitivity of dose to overall scenario assumptions (and the associated parameter assumptions). The reviewer will consider both the magnitude and time of the peak dose from these scenarios. If peak dose from the unlikely land use scenarios is significant, the licensee would need to provide greater assurance that the scenario is unlikely to occur, especially

during the period of peak dose. The licensee may be able to show that the compliance scenario bounds the results of all or many of the scenarios associated with the unlikely land uses.

I.3.4 Generic Examples

The following examples are provided as situations where the default pathways may be removed or modified. Note, the examples assume that an adequate level of justification has been provided by the licensee.

I.3.4.1 Removal of Ground Water Pathways

A licensee has extensive contamination of the upper soil horizon and the upper aquifer, which is unconsolidated and the licensee wishes to remove the ground water pathway because the upper aquifer would not be used as a water source. The aquifer shows relatively high levels of microbial activity, turbidity, and nitrates. In addition, adjacent to the site is a small patch of wetlands that shows a great deal of communication with the upper aquifer. The potential yield rate of the upper aquifer is sufficient for domestic use, but there is a better-quality, confined aquifer, whose horizon is at a depth of approximately 30 meters (100 feet). The licensee also has demonstrated that the deeper aquifer will not become contaminated from the upper aquifer. Considering all of these reasons in combination, it is questionable whether the upper aquifer would actually be used. Although it may be possible for someone to treat the contaminants and use the aquifer, there are better sources of water easily available. After consultation with the EPA and the State, it is agreed that it would be unreasonable to assume someone would use the upper aquifer as a water source. Therefore, the licensee is allowed to remove the ground water pathway from the scenario.

I.3.4.2 Scenario Development for Buried Residual Radioactivity

I.3.4.2.1 Example 1: Subsurface Soil

A site has residual radioactivity buried at a few feet below the surface and the licensee is requesting unrestricted release. The residual radioactivity does not have enough highly energetic gamma-emitters to result in an external dose in the current configuration. Two exposure scenarios can be developed (without any other site-specific information): (1) leaching of the radionuclides to the ground water, which is then used by a residential farmer; and (2) inadvertent intrusion into the buried residual radioactivity by house construction for a resident farmer with the displaced soil, which includes part of the residual radioactivity, spread across the surface. Exposure scenario 2 encompasses all the exposure pathways and, although not all of the source term is in the original position, leaching may occur both from the remaining buried residual radioactivity and the surface soil. Except for cases where an additional 0.6 m (2 ft) of unsaturated zone may make a tremendous difference in travel time to the aquifer, the ground water concentrations should be similar and, therefore, analysis of the second exposure scenario

appears to be the appropriate scenario for the critical group exposure. This example is described in greater detail and integrated with the other guidance in Appendix J of this volume.

I.3.4.2.2 Example 2: Embedded Piping

At another site, the licensee is requesting unrestricted release of its site. It is removing the buildings, but is evaluating the need to remove the concrete pads, which have embedded piping that contains the residual radioactivity. Two scenarios can be reasonably envisioned. The first scenario involves a resident farmer onsite. The farmer builds a house on the concrete pad, without disturbing the embedded piping. Possible exposure pathways would be external dose from the piping and exposure to leached materials from the piping through ground water use (e.g., drinking, irrigation, etc.). The second is similar to the building renovation scenario, where the concrete pad and piping are removed from the site. The licensee should investigate both to find the limiting scenario.

I.3.4.3 Scenario Development for Restricted Release

The site restrictions planned for an alternate site include a restriction, for this example, on the deed, on the use of the property for only parkland, and an engineered cover is placed over the residual radioactivity. The engineered cover is contoured for use as parkland and has a vegetative cover (i.e., not a mound covered in rip-rap). Three scenarios are easily envisioned for the restricted release analysis. The first is recreational use of the property as a city park or golf course, which would limit exposure scenarios to possible external exposure. The second would involve offsite use of ground water that contains radionuclides leached from the buried residual radioactivity. The default offsite user would be a resident farmer using the ground water for all water needs. The third scenario would be a worker maintaining the park.

The unrestricted case would involve the removal of the institutional control (i.e., the deed restriction) and failure of the engineered cover. Again, two main scenarios can be envisioned.

The first scenario is similar to the default exposure and would involve a residential farmer that uses ground water from the aquifer under the site. The engineered cover may have been compromised by the placement of the buildings, but the cover may still work in some degraded function (e.g., the water infiltration rate would increase from the design rate to some higher rate, but probably not as high as the infiltration rate would have been if the cover had never been constructed). Whether buried residual radioactivity had been transported to the surface by the construction of a basement under the resident farmer's house would depend on the thickness of the engineered cover. If typical basement depth were deeper than the engineered cover's thickness, some portion of residual radioactivity would be transported to the surface, mixed with the "clean" cover material, and spread over the site.

The second scenario would involve possible erosion of the cover and subsequent exposure of an onsite resident to the buried radionuclides or radionuclides redistributed by surface water. The exposure scenario would still be a resident farmer. The reasonableness of this scenario would depend on the thickness and erosion-resistence of the engineered cover.

Changes to NUREG-1757, Vol. 2, Appendix M, "Process for Developing Alternate Scenarios at NRC Sites Involved in DandD and License Termination"

Note that some of the Web addresses may no longer be valid due to both the fluid nature of the Internet and the age of the document (the document was produced in the spring and summer of 1998).

Acronyms

BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	Decontamination & Decommissioning
DoD	Department of Defense
GIS	Geographic Information Systems
HLW	High Level Waste
IHI	Inadvertent Human Intruder
LLW	Low Level Waste
MOP	Member of Public
NEA	Nuclear Energy Agency
NRCS	Natural Resources Conservation Service
NWPA	Nuclear Waste Policy Act
OSWER	Office of Solid Waste and Emergency Response
RCRA	Resource Conservation and Recovery Act
SCS	Soil Conservation Service
SNL	Sandia National Laboratories
USDA	U.S. Department of Agriculture
WIPP	Waste Isolation Pilot Plant

M.1 Introduction

M.1.1 Purpose

The process for developing alternate scenarios complements the Decisionmaking Framework and is meant to be used in conjunction with the methodology discussed in Section 1.2 of this volume and in the guidance on scenarios, exposure pathways, and critical groups discussed in Section I.3 from Appendix I.

As noted in Section I.3, this Appendix is primarily focused on users that have chosen to create site-specific scenarios by modifying the basic screening scenarios based on physical considerations of the site. Licensees also are free to construct scenarios by other methods, and, depending on the reasonably foreseeable land use and unlikely uses, may not need to address the screening scenarios. See Section I.3 for more details. This Appendix, while constructed as a method of modifying the screening scenarios, may still be useful to other scenario generation methods. Specifically, a licensee may try to find a scenario on a later panel that approximates the site-specific land use assumptions and start there. In addition, most licensees may find the discussions on sources of data for various aspects that relate to their site useful.

Two basic screening scenarios are used; the residential farmer and the building occupancy scenario. The residential farmer scenario is meant to be applied to sites with land and water residual radioactivity and the building occupancy scenario is to be applied to sites with contaminated structures. A generic critical group, with acceptable default parameter values to represent the average member of each group is associated with each scenario. The default pathways, models and parameter values for the critical group combine to form exposure scenarios.

This appendix steps through the process for eliminating the various pathways from the residential farmer scenario and describes the associated information needed to justify the actions. This is a simple illustration of the process. Following the illustration methodically will not always identify the scenario containing the critical group for a site-specific scenario. As illustrated, the process assumes that the combination of radionuclides and remaining pathways will result in the resident still getting the highest dose. However, in some cases, other scenarios, including offsite use of materials, could become the critical group's scenario. For example, a construction scenario may become more important than a residential scenario for certain radionuclides.

M.1.2 Background

There is significant variability among decommissioning sites with respect to geography and site residual radioactivity. The original purpose of the site, historical development, and the resulting processes that generated the site residual radioactivity vary widely. Residual radioactivity has occurred in buildings, process equipment and other site structures, soils (surface and subsurface),

ponds, lagoons, surface waters, and ground water. Sites are located in urban and suburban, residential, commercial and industrial, rural, and agricultural areas, and many are located on or directly adjacent to rivers, lakes, oceans, estuaries, wetlands, flood plains, or wildlife areas. The waste form is highly variable as slag, general soil or sediment residual radioactivity, sludge, debris, dust or sand piles, packaged (drums, crates, etc.), and dispersed in liquid media.

In general, scenarios represent possible realizations of the future state of the system (Cranwell *et al.*, 1990). Scenarios are needed to establish potential future conditions which might lead to human exposure.

M.2 Process Schematic

The process for developing alternate scenarios is presented in this report as a twelve-panel schematic flow diagram (Figures M.1 through M.12). This diagram is supported by text in Sections M.3, M.4, and M.5.

The schematic begins with the definition of the source and describes a step-by-step procedure of using site-specific information to alter the resident farmer scenario by removing pathways. The supporting text should be referred to for specific details about steps, standards, and data needed to defend the removal of a pathway.

Although this step-by-step process provides an efficient way to introduce site-specific data to rule out pathways, shortcuts can be and should be taken at specific points in the process when data developed by the decision analysis warrants it. For example, if the decision analysis shows the aquatic pathway to be primary in the computation of the TEDE, then the licensee when using this process should skip other pathways and focus on evidence that could either rule out the aquatic pathway or make the dose estimate more realistic.

If the residual radioactivity at a site is fully contained within a building (and would reasonably be expected to remain there throughout the period when it could cause a TEDE greater than the threshold), the default resident farmer scenario would not be applicable and the licensee should use the building occupant scenario.

M.2.1 Panel 1: Beginning the Process

The first panel (Figure M.1) begins with a more detailed version of the Decision Framework (Section 1.2 of this volume) and shows the context of this process in relation to that framework. This panel takes the licensee from defining the source through initial and iterative dose assessments, to sensitivity and decision analyses, and finally to the use of site-specific information to develop alternate scenarios.

While this schematic shows other actions that can be taken subsequent to the sensitivity analysis, the schematic (and this report) concentrate solely on those actions associated with the process for developing alternate scenarios through the introduction of specific information. Other actions include using site-specific information to modify pathway parameters, changing or altering the pathway models, releasing a license for restricted use, and cleaning up the site.

Section M.3 of this appendix (Initial Computation) provides descriptions of processes shown in Panel 1 (Figure M.1) with regard to the source definition and the initial and iterative dose assessments. Section M.4 (Sensitivity Analysis) describes a sensitivity analysis process and presents an example of both text and graphics reports developed using the NRC software DandD 1.0. This example shows how a sensitivity analysis can help the licensee understand which specific pathway and radionuclides dominate the computed dose.

If the initial computation results in a TEDE to an average member of the critical group that exceeds 0.25 mSv/y (25 mrem/y), the licensee would proceed to Panel 2 (Figure M.2) to consider land use. The projected use of the land is critical to beginning of this process. If the future use of the land is shown to be urban or industrial, rather than the default resident farmer, the starting scenarios contain significantly fewer pathways than the resident farmer scenario and the TEDE should always be significantly lower than the initial TEDE.

M.2.2 Panel 2: Land Use Data

The second panel (Figure M.2) illustrates the decisions necessary to determine if there is sufficient evidence to bypass the resident farmer scenario and go directly to an urban or industrial worker scenario. These decisions are based on the persistence of the TEDE over the 0.25 mSv/y (25 mrem/y) threshold and on the current and projected land use at the site. Future land use should be projected for the time period that the TEDE is expected to be greater than the 0.25 mSv/y (25 mrem/y) threshold.

One hundred years is considered a reasonable cutoff point for future land use projections. If the future land use can reasonably be predicted (i.e., within 100 years) to be either urban or industrial, the resident farmer scenario can be bypassed, allowing the licensee to concentrate on these land uses. See Section I.3 for more information on justifying and selecting reasonably foreseeable land uses.

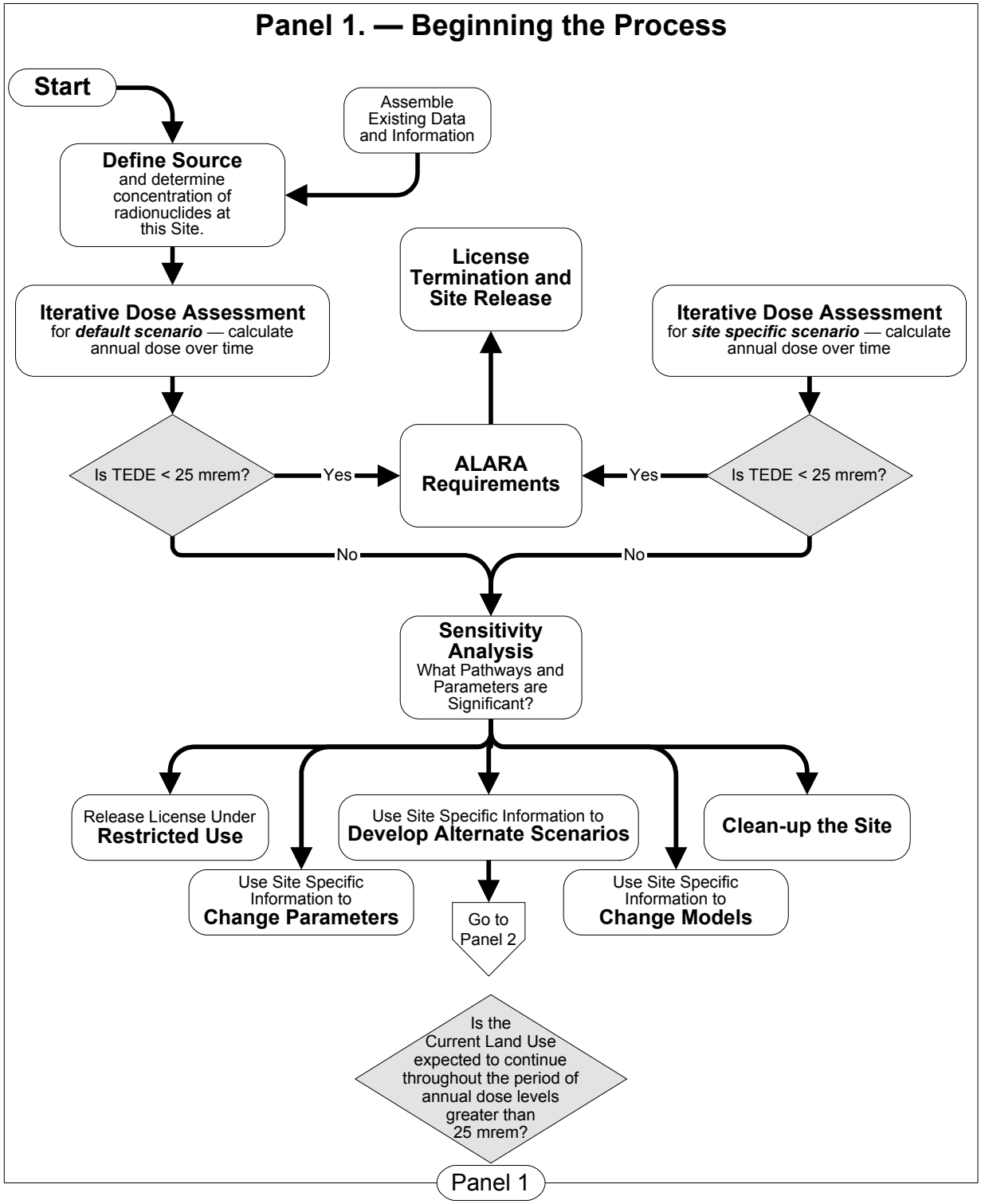

Figure M.1 Panel 1: Beginning the Process.

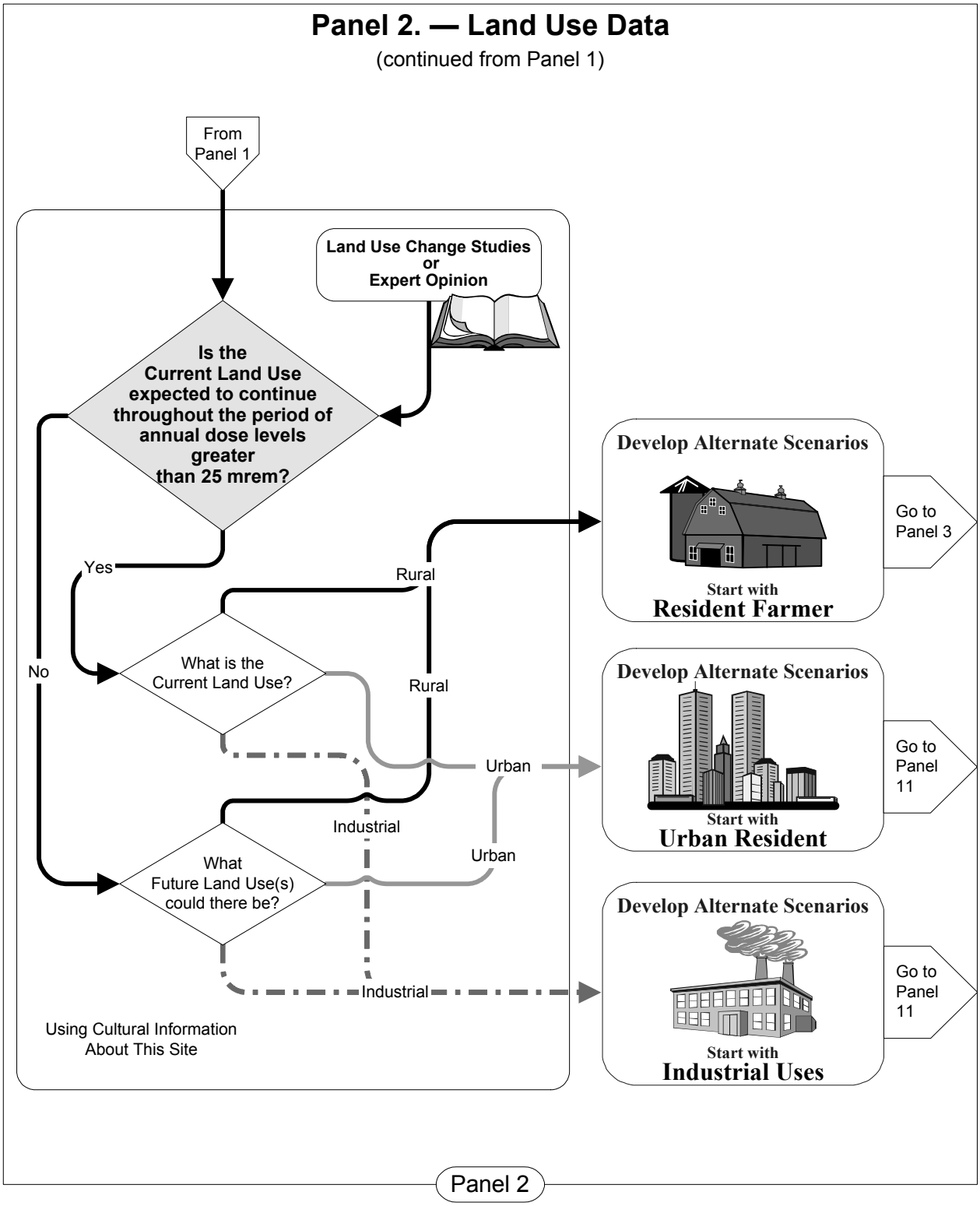

Figure M.2 Panel 2: Land Use Data.

Section M.5.1 presents procedures for determining current land use and for estimating future land use. It also presents tables of Web sites where land-use information might be obtained.

Panel 2 (Figure M.2) will direct the licensee to Panel 3 (Figure M.3), to begin the process of devolving the resident farmer scenario by removing pathways, to Panel 11 (Figure M.11) where the urban resident and the industrial worker scenarios are considered, or to both if multiple land uses are viable.

M.2.3 Panel 3: Start with Resident Farmer — Ground Water — Limited Use

The third panel (Figure M.3) is a continuation of Panel 2 and begins the process of introducing physical information about the site. The starting point here is the resident farmer scenario with all pathways (the default scenario). Since water is critical to the key pathways in this scenario, the first question to ask is "Is ground water available?"

If the answer to this question is "Yes," it may be available for only limited uses, depending on the ground-water yield. Section M.5.2.1 addresses the availability of ground water and the documentation that would need to be submitted to NRC if the licencee wants to remove or limit the ground water pathway on the basis of ground water unavailability. If the yield is great enough to satisfy all uses, Panel 3 (Figure M.3) will direct the licensee to Panel 5 (Figure M.5), to consider the suitability of ground water as an environment for the resident farmers' fishery. If the yield can only sustain irrigation and drinking water, Panel 3 will direct the licensee to Panel 6 (Figure M.6), to consider the suitability of ground water for agriculture. If the yield would limit the use to household and drinking water only, Panel 3 will direct the licensee to Panel 8 (Figure M.8), to consider the potability of ground water.

If ground water is not available, the ground water pathway (and all pathways that depend on ground water) would be removed from the resident farmer scenario, resulting in a resident farmer scenario where all water needs are assumed to be met through the use of an outside, uncontaminated water source. The licensee would review Panel 4 (Figure M.4) to consider the resident farmer scenario without ground water.

M.2.4 Panel 4: Agriculture — No Pond

The fourth panel (Figure M.4) is a continuation of Panel 3 and continues the process of introducing physical information about the site. If ground water has been documented to be unavailable, an iterative dose assessment should be done to see if the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y). If it still exceeds this threshold value, the next logical question to ask is "Are soil and topography at this site suitable for agriculture?" The details of this issue are addressed in Section M.5.2.2.

If the answer to this question is "No," that either soil or topography at this site are determined to be unsuitable for agriculture, and the agricultural pathway would be removed resulting in a scenario that has a rural resident with no agriculture, pond, or drinking water, since the ground water pathway had already been removed. The resident farmer scenario has now devolved into a what is essentially a building occupancy scenario combined with modified external exposure and inhalation pathways. Section M.5.2.2 describes the documentation that should be submitted to NRC if the licencee wants to remove the agricultural pathway on the basis of either topography or soil being unsuitable to agriculture.

After the agricultural pathway is removed, another dose assessment would be done for a scenario that includes only the building occupancy scenario and external exposure and inhalation pathways. These pathways should be modified to reflect that the resident is no longer working on the "farm." If the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin a more critical analysis of the pathway parameters for the pathways in this scenario, but there is no need, at this point, to continue with alternate scenario development.

M.2.5 Panel 5: Aquatic Life

The fifth panel (Figure M.5) is a continuation of Panel 3. This panel starts with a resident farmer and all pathways. Ground water is available, but is it suitable for aquatic life?

Section M.5.2.1.2 considers the suitability of ground water as an environment for the resident farmers' fishery and presents the standards for this water to be considered acceptable for this use. If the water is unsuitable for aquatic life, the aquatic pathway would be removed, resulting in a resident farmer scenario with no pond. An iterative dose assessment would be performed, and if the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee would go to Panel 5 (Figure M.5) to consider the suitability of ground water for agricultural use.

If the answer to the first question is "Yes," the ground water is suitable for a pond, cultural data for the area should be introduced to answer the question, "Do residents of this area use ponds as fisheries?" See Section M.5.1.2 for more details on information sources and documentation needed. If the answer is "No," the licensee would proceed as in the previous paragraph for the removal of the aquatic pathway and subsequent analyses, including iterative dose assessment. If the answer is "Yes," the licensee would go to Panel 7 (Figure M.7) to consider the suitability of ground water for agriculture.

Figure M.3 Panel 3: Start with Resident Farmer — Ground Water Availability.

[Figure M.3 not modified and not included in this draft.]

Figure M.4 Panel 4: Agriculture — No Pond.

[Figure M.4 not modified and not included in this draft.]

Figure M.5 Panel 5: Aquatic Life.

[Figure M.5 not modified and not included in this draft.]

M.2.6 Panel 6: Agriculture — No Pond

The sixth panel (Figure M.6) is a continuation of Panel 5. This panel starts with a resident farmer without a pond. Ground water is available, but it is not suitable for a pond. The question asked here: "Is the ground water quality suitable for agricultural use?"

Section M.5.2.1.3 considers the suitability of ground water for agriculture and present the standards for this water to be considered acceptable for this use. If the water is unsuitable for irrigation (growing crops), it should not be considered suitable as drinking water for the farmer or for his animals. In this case, the following pathways would be removed: the irrigation pathway, the drinking water pathway, and any pathways associated with farm animals drinking water.

The resultant scenario would be a resident farmer scenario with no ground water use. All water needs would be met by uncontaminated water from an outside source, but the farmer would still be growing crops in soil with residual radioactivity, and his animals would still be ingesting food and soil with residual radioactivity.

If an iterative dose assessment shows the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the next logical question to ask is "Are soil and topography at this site suitable for agriculture?" Additional details concerning this issue can be found in Section M.5.2.2. If the answer to this question is "No," and either soil or topography at this site are determined to be unsuitable for agriculture, the agricultural pathway would be removed, leaving a rural resident with no agriculture, pond, or drinking water, since the these pathway have already been removed.

The resident farmer scenario has now devolved into a what is essentially a building occupancy scenario combined with modified external exposure and inhalation pathways. Section M.5.2.2 presents the documentation that would need to be submitted to NRC if the licencee wants to remove the agricultural pathway on the basis of either topography or soil being unsuitable to agriculture.

After the agricultural pathway is removed, another dose assessment would be done. If the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin to analyze the critical parameters for the this scenario, but there is no need, at this point, to continue with alternate scenario development.

If the answer to the question regarding the suitability of the soil and topography at this site for agriculture is "Yes," the scenario returns to that of a resident farmer with no ground water use getting all his water needs met by uncontaminated water from an outside source. For this situation, the scenario has been defined and there is no need to introduce additional site data. An iterative dose assessment should be done after critical parameters have been modified.

If the answer to the first question in this panel, "Is ground water quality suitable for agriculture?" is "Yes," the licensee would go to Panel 8 (Figure M.8) to consider the potability of the ground water.

M.2.7 Panel 7: Agriculture — All Pathways

The seventh panel (Figure M.7) is also a continuation of Panel 5, but it starts with a resident farmer and all pathways. Ground water is available and it is suitable for a pond. The question asked here is the same as in Panel 6: "Is the ground water quality suitable for agricultural use?"

The procedure here is identical to Panel 6, except that in each resultant scenario, the farmer still has a pond. In the final situation, where both questions have been answered with a "No," the scenario is of a rural resident with a pond — the building occupancy scenario combined with the aquatic scenario and modified versions of the external exposure and inhalation pathways.

If the answer to the first question in this panel, "Is ground water quality suitable for agriculture?" is "Yes," the licensee would go Panel 9 (Figure M.9) to consider the potability of the ground water.

M.2.8 Panel 8: Potability — No Pond

The eighth panel (Figure M.8) is a continuation of Panel 6, a resident farmer without a pond. Ground water is available and is suitable for agriculture, but it is not suitable for a pond. The questions asked here are "Is the ground water potable?" and "Can the farmer drink the water?".

Section M.5.2.1.4 considers the potability of ground water, drinking water standards, and documentation needed for the NRC. If the ground water does not meet drinking water standards, the drinking water pathway would be removed, and an iterative dose assessment would be done. If TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee would consider the suitability of the soil and topography for agricultural use.

This suitability of the topography and soil for agriculture would be considered in the same manner as it was in Panel 6 (Figure M.6). If either the soil or topography is determined to be unsuitable, the agricultural pathway would be removed and the scenario would devolve to the building occupancy scenario of a rural resident with no pond, no agriculture, and no drinking water.

After the agricultural pathway is removed, another dose assessment would be done, and if TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin analysis of the critical parameters for the building occupancy scenario. If the TEDE is still above the threshold value, the licensee would need to consider modifications to the critical parameters, but there would be no need, at this point, to continue with alternate scenario development.

If the answer to the first question in this panel, "Is ground water potable?" is "Yes," the licensee would go to Panel 10 (Figure M.10) to consider the potability of the ground water.

Figure M.6 Panel 6: Agriculture — No Pond.

[Figure M.6 not modified and not included in this draft.]

Figure M.7 Panel 7: Agriculture — All Pathways.

[Figure M.7 not modified and not included in this draft.]

Figure M.8 Panel 8: Potability — No Pond.

[Figure M.8 not modified and not included in this draft.]

M.2.9 Panel 9: Potability — All Pathways

The ninth panel (Figure M.9) is the continuation of Panel 7 and is almost the same as Panel 8, except that it starts with a resident farmer and all pathways. Ground water is available and is suitable for both pond and agriculture. As with Panel 8, the question asked here is, "Can the farmer drink the water?"

The procedure here is identical to Panel 8, except that in each resultant scenario the farmer still has a pond. In the final situation, where both questions have been answered with a "No," the scenario would be that of a rural resident with a pond — the building occupancy scenario combined with the aquatic scenario and modified versions of the external exposure and inhalation pathways.

As with Panel 8, if the answer to the first question in this panel, "Is ground water quality suitable for agriculture?", is "Yes," the licensee would go Panel 11 (Figure M.11) to consider the suitability of topography and soil for agriculture.

M.2.10 Panel 10: Topography and Soil — No Pond

The tenth panel (Figure M.10) is the continuation of Panel 8; it starts with a resident farmer with no pond. Ground water is available, and although not suitable for a pond, it is suitable for both

agriculture and drinking. The question here is the suitability of topography and soil for agriculture.

The question of the suitability of topography and soil for agriculture is considered in the same manner as it was for Panel 6. If either the soil or topography is determined to be unsuitable, the scenario would devolve to a rural resident with drinking water but no pond. This would essentially be the building occupancy scenario combined with the drinking water scenario, and modified versions of the external exposure and inhalation pathways.

After the agricultural pathway is removed, another dose assessment would be done, and if the TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin analyzing of the critical parameters for this scenario, but there would no need, at this point, to continue with alternate scenario development.

If the answer to the first question in this panel regarding the suitability of topography and soil for agriculture is "Yes," the licensee would assume that the correct scenario is the resident farmer with all pathways except a pond, and would begin examining critical parameters for that scenario using information from a sensitivity analysis.

M.2.11 Panel 11: Topography and Soil — All Pathways

The eleventh panel (Figure M.11) is the continuation of Panel 9; it starts with a resident farmer and all pathways. Ground water is available and has been determined to be suitable for a pond, for agriculture, and for drinking. The question now is the suitability of topography and soil for agriculture. This suitability of topography and soil for agriculture is considered here in the same manner as it was in Panel 6. If either the soil or topography is determined to be unsuitable, the scenario would devolve to a rural resident with drinking water and a pond. This would essentially be the building occupancy scenario combined with the drinking water scenario, the aquatic scenario, and modified versions of the external exposure and inhalation pathways.

After the agricultural pathway is removed, another dose assessment would be done and if TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin analysis of the critical parameters for this scenario, but there would be no need, at this point, to continue with alternate scenario development.

If the answer to the first question in this panel regarding the suitability of topography and soil for agriculture is "Yes," the licensee would assume that the correct scenario is the resident farmer with all pathways and would begin examining critical parameters based on a sensitivity analysis.

Figure M.9 Panel 9: Potability — All Pathways.

[Figure M.9 not modified and not included in this draft.]

Figure M.10 Panel 10: Topography and Soil — No Pond.

[Figure M.10 not modified and not included in this draft.]

Figure M.11 Panel 11: Topography and Soil — All Pathways.

[Figure M.11 not modified and not included in this draft.]

M.2.12 Panel 12: Urban Resident and Industrial Uses

The twelfth panel (Figure M.12) is the continuation of Panel 2; it starts with the urban resident scenario and shows the industrial uses scenario.

M.2.12.1 Urban Resident

The urban resident scenario is essentially a building occupancy scenario that includes a garden scenario (modified from the resident farmer scenario) and modified versions of the external exposure and inhalation pathways. Cultural information regarding future land use needs to be introduced here to answer the question, "Is this urban resident likely to have a garden?" The information presented in Section M.5.1 and specifically M.5.1.2.2 can be used to help answer this question and determine the documentation that would need to be submitted to the NRC on this issue.

If the urban resident is likely to have a garden, the licensee should begin analyzing of the critical parameters for this scenario, but there would be no need, at this point, to continue with alternate scenario development.

If it is considered unlikely for the urban resident to have a garden, the garden pathway would be removed, an iterative dose assessment would be done. If TEDE to an average member of the critical group still exceeds 0.25 mSv/y (25 mrem/y), the licensee should begin analyzing of the critical parameters for the urban resident scenario, but there would be no need, at this point, to continue with alternate scenario development.

M.2.12.2 Industrial Worker

The industrial worker scenario includes the building occupancy scenario and modified versions of the external exposure and inhalation pathways. While there is no additional site-specific information to further devolve this scenario, site-specific information can be used to modify the pathway parameters for this scenario.

Figure M.12 Panel 12: Urban Resident and Industrial Uses.

[Figure M.12 not modified and not included in this draft.]

M.3 Initial Computation

The process for developing alternate scenarios begins with the decommissioning and license termination framework as described in Section 1.2 of this volume. The process described in this report integrates with the Decision Framework and expands upon the introduction of site-specific information, the revision of pathways, and iterative dose assessment. Figure M.1 shows a more detailed framework diagram that includes the sensitivity analysis step and highlights the process that uses site-specific information to develop alternate scenarios.

M.3.1 Define Source

M.3.1.1 Assemble Existing Data

Existing data for the site should be gathered, assembled, and evaluated. The first step is to determine the types and amounts of radioactive material possessed by the licensee at this site; this information is needed to perform the initial dose assessment.

Information about any surveys and leak tests that have been performed, as well as any records important to decommissioning as described in 10 CFR Parts 30.35, 40.36, 50.75, 70.25, and 72.30, need to be assembled as appropriate. This information may be needed to quantify the amount of residual radioactivity present at the site.

Information regarding ground water depth and quality, soil type, and local cultural practices may be needed to develop alternate scenarios, to evaluate models, or to modify model parameters, but an initial dose assessment can be performed before expending resources to gather this data. If the initial dose assessment, using site-specific source concentrations, default pathways, and default pathway parameters, shows TEDE to an average member of the critical group to not exceed 0.25 mSv/y (25 mrem/y), there is no reason to gather and evaluate this site-specific information.

M.3.1.2 Calculate Source Concentration

The calculation of source concentration should be done according to the guidance in Appendix I.2 of this volume.

M.3.2 Initial Dose Assessment

Since the process for alternate scenario development set forth in this document is essentially a devolution of the resident farmer scenario, the initial dose assessment should be done using the default resident farmer scenario with its associated default pathways and parameters. Within this process of devolution, pathways should be removed as appropriate site-specific information is introduced.

The exception to this would be where the residual radioactivity at a site is fully contained within a building. If the case can be made that the contaminant would remain in the building throughout the period when it could cause a TEDE to an average member of the critical group to exceed the 0.25 mSv/y (25 mrem/y) threshold, the default resident farmer scenario would not be applicable and the building occupant scenario should be used.

Whenever pathways are removed, the licensee is expected to perform an iterative dose assessment that reflects the new scenario. These recurring computations are best done using software which has (1) the built-in NRC–approved default parameters and pathways, (2) procedures for removing entire pathways, and (3) procedures for modifying pathway parameters.

If the initial dose assessment results in an TEDE to an average member of the critical group that does not exceed 0.25 mSv/y (25 mrem/y), there is no need to collect more data or to develop alternate scenarios for this site. After ALARA concerns have been met, the site would be considered a candidate for unrestricted use.

If this dose assessment results in an TEDE to an average member of the critical group that is greater than 0.25 mSv/y (25 mrem/y), one of the options is to use site-specific information to modify the resident farmer scenario by eliminating pathways that are inappropriate for the site in question. There are other options at this point, but this appendix concentrates on the development of alternate scenarios.

If the process presented in this report is followed, the amount of data that needs to be gathered and the level of analyses that need to be done should be kept as low as possible. The first step in this process is to perform a sensitivity analysis by examining the results of the initial dose assessment to determine the pathways and radionuclides that significantly influence the TEDE. Section M.4 provides greater detail on this procedure and gives a specific example of a sensitivity analysis.

M.3.3 Iterative Dose Assessment

Iterative dose assessments should be done whenever a pathway is eliminated or parameters are modified. Since the process began with the resident farmer scenario and default pathways and parameters, the introduction of site-specific data should reduce the TEDE.

If at any point in the process, the iterative dose assessment shows the TEDE to an average member of the critical group does not exceed 0.25 mSv/y (25 mrem/y), there is no need to introduce more data nor to continue developing alternate scenarios. After ALARA concerns have been met, the site should be acceptable for release.

M.4 Sensitivity Analysis

If the dose assessment shows that the results exceed 0.25 mSv/y (25 mrem/y) TEDE to the average member of the critical group persists, the results of initial or iterative dose assessments need to be examined to determine which of pathways and parameters are significant. This sensitivity analysis should help the licensee concentrate subsequent analyses on those pathways or parameters that are major contributors to the TEDE. It is for these pathways or parameters that the inclusion of site-specific data should most likely reduce the TEDE. As the licensee moves through this process, the licensee should take shortcuts, jumping to those pathways that are significant and ignoring those that are not.

A simple sensitivity analysis can be done following the initial dose assessment and following each iterative dose assessments as pathways are eliminated or parameters are modified. The results of the dose assessment should show the percentage of the TEDE attributable to each major pathway and to each of the radionuclides.

M.5 Introducing Site-Specific Information

Site-specific information can be divided into two broad categories: cultural information and physical information. Physical information includes the location, climate, topography, geology, soil types, water availably, etc. of the site. Cultural information is essentially how the land is used by the human population. Physical properties of land are essentially unchanging, while cultural properties are constantly changing. In reality, physical properties change (sometimes as a result of cultural activities), but the change is slow compared to the cultural use of the land.

Since the initial dose assessment for this process was done using the resident farmer scenario with NRC–approved default pathways and parameters, the introduction of either cultural or physical information about a D&D site is likely to reduce the TEDE.

M.5.1 Cultural Information

For developing alternate scenarios, the most important element of cultural information about any site is the future land use, because radionuclides can persist over long periods of time. The future is assessed on the basis of the past and the present. Experience has shown that while this is an inexact science, the near future can be estimated with some degree of accuracy. What is the near future? It depends on the location, the culture, and what is being estimated. In this time and space, and for what is being predicted, it is probably substantially less than 100 years, but the line should be drawn somewhere, and in this case, it is drawn at 100 years. The key to the

assessment of future land use is the current and past use of the land, at both the site and in the region. The licensee will need to address both the dose from reasonably foreseeable land use (for the compliance calculation) and unlikely land uses (for informational purposes).

M.5.1.1 Current Land Use

The determination of current land use is the initial step in the process of estimating future land use. Land use should be determined not only for the site, but also for the land within a 80-km (50-mile) radius surrounding the site. This assessment of land use does not need to be complicated or detailed; it should be fairly simple, dividing the land into only three categories: urban, rural, or industrial.

Current land use can be determined through one or more of the following information sources:

- site description,
- topographic maps,
- planning agencies,
- zoning maps,
- aerial photographs, or
- site visits.

The majority of the US has codified land use/zoning, and many administrative areas have developed land use master plans. For this reason, the primary source of information on current land use should be the planning agencies of the state, county, and/or municipality in which the D&D site resides. In most cases, the easiest way to find these planning agencies is in the government section of the local phone book.

There is also a large amount of data available on the Internet at Web sites maintained by government agencies. Tables M.1, M.3, and M.4 list current Web sites for every state in the U.S. These Web sites contain indices to all types of data about each specific state. Examples of the types of information available are given in Table M.2. Land use planning information is often available at these sites. (Note: Web sites are volatile. Addresses, the amount, and type of information at any Web site may change at any time.)

Table M.1 State Web Sites

[Table M.1 not modified and not included in this draft.]

Table M.2 Land Use Information Types

[Table M.2 not modified and not included in this draft.]

Table M.3 Federal Sites Containing Data Relevant to Land Use

[Table M.3 not modified and not included in this draft.]

Table M.4 State Sites Containing Data Relevant to Land Use

[Table M.4 not modified and not included in this draft.]

Assumptions and predictions regarding future land uses are important considerations in the development of scenario definitions and descriptions for analysis. If the site currently exists in a highly populated urban area, a residential farmer scenario is very unlikely. Exposure scenarios for certain sites may exclude exposures via agricultural pathways if agricultural land uses are clearly incompatible with existing and anticipated future conditions at the sites. Exposures via ingestion of contaminated ground water may be discounted if the affected ground water is of such poor quality as to preclude human consumption.

M.5.1.1.1 Use of Ponds as Fisheries

In addition to physical limitations on the likelihood of a farmer using a pond as a fishery, local cultural information should be used to determine if local residents currently engage in this practice. This question might be answered by the USDA county extension agent nearest to the D&D site. Contact information for county extension agents can be found at: <http://www.reeusda.gov/>.

M.5.1.2 Future Land Use

Specific local conditions should be taken into account when deciding how far into the future land use can be estimated. The general range for estimation is within 100 years. In areas where rapid change has occurred in the past, this cutoff might be considerably less than 100 years, whereas in other areas, such as the heart of New York City, it may be reasonable to argue that urban conditions should prevail for more than 100 years.

The first step in estimating future land use is to determine the current land use at the site. The past use of the land should also be ascertained because it is the combination of past and present uses that should indicate what changes have occurred and the rate of those changes. This information should be used in a documented process that a reviewer would be able to follow. This documentation should include the types and sources of material that were used and how the final projected use was determined. Tables M.1, M.3 and M.4 list possible Web site sources that may contain useful information.

Land use and changes in land use within the 80-km (50-mile) radius of the site should be considered as part of this process. For example, a site that is currently located in a rural area within 16–32 km (10–20 miles) of a growing metropolitan area should likely be in the suburbs of the metropolitan area within a decade or two, depending on population growth.

The 80-km (50-mile) radius is only a suggestion for determining the size of the area to consider. There may be valid reasons for increasing or decreasing the area of consideration, depending on local conditions and the length of time that a TEDE greater than the 0.25 mSv/y (25 mrem/y) threshold is expected to occur. Other factors that may influence this decision are critical pathways and the estimated distribution of residual radioactivity.

M.5.1.2.1 Sources of Information for Determining Future Land Use

The primary document referenced for information types was EPA OSWER Directive No. 9355.7–04: Land Use in the CERCLA Remedy Selection Process, dated May 25, 1995. This directive by the EPA's Office of Solid Waste and Emergency Response (OSWER) is also referenced by the Department of Defense (DoD) for use in Base Realignment and Closure (BRAC) installations.

Based on the OSWER directive, and on personal experience, Tables M.1, M.3, and M.4 contain information types which were used in determining possible data/information sources.

The are many sources at the Federal, State, and local levels for the information types listed in Table M.2. The list of sources provided here is not definitive, but the sources listed should, in most cases, be able to point the licensee to additional sources of information.

Because so much of the information used to describe current land uses and to determine possible future land uses is geographic in nature, the sources provided are for government geographic information system (GIS) providers at both the national and state levels. State GIS organizations should be able to direct the licensee to local sources for much of this information and, in many cases, may have links to that information directly from their data sites.

Table M.3 lists Federal government sources for data useful for determining possible future land use, and Table M.4 lists each state and the corresponding location for digital data.

M.5.1.2.2 Urban Gardens

The subsistence farm associated with the resident farmer is unlikely to exist in an urban situation, but gardens are very likely in urban and suburban settings. The "Victory Gardens" of World War II demonstrate this possibility. Exceptions would be places like the concrete and steel core of large cities like New York, where gardens would be highly unlikely.

Documentation to be Submitted to NRC

Current Land Use should be documented by maps, descriptions, or information from one of the other sources listed in Tables M.1, M.3, and M.4.

Estimates of Future Land Use should be supported by the documented process described in Section M.5.1.2.

M.5.2 Physical Information about Site

Physical information about the site includes climate, topography, vegetation, and, most importantly, water. Since water is a key factor in many of the pathways, its availability and proximity are very important.

M.5.2.1 Ground Water and Surface Water

Ground water is present at some depth at most every site. If ground water is only found at great depths, surface water may be ephemeral and may exist only in response to rainfall or snowmelt. Surface water for the resident farmer is a fish pond that is connected to the ground water.

There are several key questions about ground water that should be answered using site-specific information. The most important question regards the availability of water. Subsequent questions regard its quality and suitability for use.

M.5.2.1.1 Is Ground Water Available?

The first question that should be answered is "Is ground water available as a resource for the scenario resident?" More specific questions include the following:

1. Is it shallow enough and does it have sufficient yield such that it can reasonably be pumped by the resident to irrigate a small farm and provide domestic drinking water?
2. Is it shallow enough to intercept and connect to a fish pond, and does it have sufficient yield to sustain the pond?

With regards to the first question, the resident would need to drill a well into a permanent aquifer that has water sufficient for his needs and then be able pump that water into his house and onto his crops. Under the assumption that the well drilling and pumping technology available to the resident is similar to what exists today, it would not be unreasonable for the farmer to drill a well to and pump from a depth of 120 m (400 ft), but this depth should be considered somewhat

subjective. Specific local conditions should be considered when deciding how deep an aquifer a subsistence farmer would be able to use. A commercial farmer would be likely to drill much deeper than a subsistence farmer would.

Local trends in ground water decline should be taken into account. In areas where ground water is being withdrawn at an unsustainable rate, water levels may be dropping. If it can be reasonably assumed that this trend may continue into the future, this should be taken into account when assessing the availability of ground water for the resident farmer.

If ground water is not available at a reasonable depth for drinking water or irrigation, it may also not be available for a pond. Under these circumstances, the resident farmer scenario can be devolved to exclude all three of the major pathways based on ground water usage: irrigation, drinking water, and aquatic (pond). If ground water is unavailable, it is also reasonable to exclude the use of surface water, since the aquatic scenario considers the concentration of radionuclides in the surface water to be related to the concentration in the ground water aquifer [Kennedy, 1992].

Even if ground water were available at reasonable depth, the yield may be insufficient for all uses. Under these circumstances, the resident farmer scenario can be devolved to exclude major pathways that cannot be satisfied by the yield.

Documentation to be Submitted to NRC

Ground Water Unavailable: USGS or independent consultant report showing that either ground water does not exist, or that it is too deep >120 m (>400 ft) to reasonably be used by a subsistence farmer.

If ground water is available for drinking or irrigation, it may not be available for a fishery pond. It would not be reasonable to expect that the farmer would continually pump water into a pond to maintain it as a fishery. The ground water would have to be shallow enough that a sufficient pond level would be maintained through its connection to the pond. This would mean the ground water would have to be no deeper than about 5 m (15 feet). Information about local topography and specific conditions at each site could be used to adjust this number up and down. If ground water is not available for the pond, the aquatic pathway should be removed from the resident farmer scenario.

Documentation to be Submitted to NRC

Ground Water Unavailable for Fish Pond: USGS or independent consultant report showing that either ground water does not exist, or that it is too deep (>15 ft.) to connect to a surface water pond.

M.5.2.1.2 Is Ground Water Quality Suitable for Aquatic Life?

The quality of surface water is critical to the support of aquatic life and is affected by (1) the chemical and physical conditions that exist in the pond, (2) runoff from exposed soil, and (3) condensation/entrapment of contaminants from the air (e.g., pollutants, acid rain, etc). Recommended standards for surface waters have been proposed [Viessman and Hammer, 1985] and are listed in Table M.5.

Table M.5 EPA Standards for Surface Waters to Support Freshwater Aquatic Life

[Table M.5 not modified and not included in this draft.]

The concentration of dissolved oxygen in surface water is affected by the biochemical oxygen demand (BOD) of the ecosystem. Sedimentation of suspended solids can cause a buildup of organic matter in sediments. These materials undergo metabolic degradation by aerobic soil microorganisms with the concomitant depletion of dissolved oxygen. Other contaminants, such as dissolved ammonia, can contribute to oxygen depletion by nitrification. Ammonia is toxic to fish and other aquatic animals. Acute toxicity occurs to warm-water species at ammonia levels of 0.4 mg/L.

The presence of coliform bacteria is sometimes indicative of other, more virulent pathogens in surface water and should be considered when fish or other aquatic animals are produced for human consumption.

If the quality of the ground water (and hence the pond) lies outside of the acceptable standards for aquatic life, the aquatic pathway should be removed from the resident farmer scenario.

Documentation to be Submitted to NRC

Ground Water Unsuitable for Aquatic Life: USGS or independent consultant report showing that ground water quality is poorer than the standards listed for this use.

M.5.2.1.3 Is Ground Water Quality Suitable for Agriculture?

The quality of ground water for agricultural uses varies depending on the type of agribusiness or agricultural enterprises conducted at the site. For example, ground water with infiltrated fertilizers and herbicides can be very beneficial to crop land through irrigation, but can have an adverse effect on the health and productivity of livestock and poultry. Based on extensive studies by the USDA, recommended limits for chemicals in drinking water for livestock and poultry have been published [<http://www.montana. edu/wwwpb/ag/baudr146.html>, <http://www.cahe.nmsu.edu/pubs/_m/m-112.html>]. Table M.6 identifies common

contaminants in ground water and the recommended maximum concentrations for consumption by livestock and poultry.

Table M.6 Recommended Limits for Components in Drinking Water for Livestock and Poultry

[Table M.6 not modified and not included in this draft.]

In additional to acute and chronic toxicity from the elements in Table M.6, high concentrations of dissolved solids in drinking water can lead to various degrees of mineral toxicity in animals. Most minerals and dissolved solids found in water provide nutritional benefits when present within limited concentration ranges (e.g., selenium). At high concentrations, however, common minerals can lead to acute or chronic effects that impact the quality of animal products and overall productivity.

The salinity, or total dissolved solids, should be a consideration when evaluating ground water for animal consumption. Although 10,000 mg/L is acceptable under some conditions, the health, and ultimately the productivity, of animals is affected to various degrees by the salinity. Table M.7 provides a breakdown of conditions that have been observed and documented in livestock and poultry for various concentrations of dissolved solids in drinking water.

Table M.7 Effects of Salinity of Drinking Water on Livestock

[Table M.7 not modified and not included in this draft.]

If the quality of the ground water is less than what is considered acceptable for irrigation, the irrigation pathway should be removed from the resident farmer scenario.

If the quality of the ground water is less than what is considered acceptable as a drinking source for farm animals, that pathway should be removed from the resident farmer scenario.

Documentation to be Submitted to NRC

Ground Water Unsuitable for Agriculture: USGS or independent consultant report showing that ground water quality is poorer than the standards listed for this use.

M.5.2.1.4 Is Ground Water Suitable for Drinking Water?

This question can be addressed by comparing the quality of the ground water with EPA drinking water standards. National Primary Drinking Water Regulations, 40 CFR Part 141 defines regulations for public water systems in the United States. Primary drinking water standards specify approval limits for microorganisms, including bacteria and viruses, specific inorganic and organic chemicals, radionuclides, and turbidity while secondary standards identified in 40 CFR Part 143, National Secondary Drinking Water Regulations, recommend limits on benign

contaminants and define physical characteristics that address aesthetics of drinking water (e.g., color and odor).

Tables M.8 to M.11 specify the Maximum Contaminant Levels (MCLs) of contaminants in drinking water delivered to any user of a public water system. The contaminants are distinguished as (1) inorganic chemicals, (2) organic chemicals, (3) radionuclides, and (4) microorganisms. Although turbidity is a measured physical parameter, it is included with microorganisms because turbid water is generally associated with microorganisms or provides a medium for microbial growth.

Table M.12 specifies recommended secondary standards for drinking water. Although the secondary standards are not regulated, they serve as a guide for water quality and may, in some instances, be regulated at the State or local level.

Documentation to be Submitted to NRC

Ground Water Not Potable: USGS or independent consultant report that shows that ground water quality is poorer than the standards listed for this use.

M.5.2.2 Topography and Soil

M.5.2.2.1 Is Soil Suitable for Agriculture?

Soil performs several functions related to plant growth. It forms a media in which roots penetrate, thereby providing a source of stability and nourishment. Nourishment can be provided by the nutrients available in the soil, by fertilizers, or by soil amendments.

Table M.8 National Primary Drinking Water Regulations for Inorganic Chemicals

[Table M.8 not modified and not included in this draft.]

Table M.9 National Primary Drinking Water Regulations for Radionculides

[Table M.9 not modified and not included in this draft.]

Table M.10 National Primary Drinking Water Regulations for Microorganisms

[Table M.10 not modified and not included in this draft.]

Table M.11 National Primary Drinking Water Regulations for Organic Chemicals

[Table M.11 not modified and not included in this draft.]

Table M.12 National Secondary Drinking Water Regulations

[Table M.12 not modified and not included in this draft.]

With suitable fertilizers or soil amendments, plants can readily be grown in "soil free" materials, such as mineral sand, gravel, perlite, pumice, crushed bricks, or glass wool. Consequently, the absence of soil in the traditional sense at a site does not eliminate plant ingestion as a pathway. Because soilless gardening requires more management than traditional gardening methods, it is more likely to be used for growing vegetables and herbs than for the production of commodity items such as grains or livestock fodder [Nicholls, 1997].

Agriculture could be excluded from a scenario if the site is an outcropping of bedrock without appreciable soil, or debris that could serve to anchor plants.

Areas consisting of made land, where there is abundant debris and cobbles with little or no soil, would not lend themselves to mechanized agriculture in short-term scenarios. In the absence of mechanized agriculture, commodity food items and fodder are not likely crops. However, it would be difficult to exclude vegetable gardens from scenarios at such sites. In addition, it would be difficult to justify exclusion of livestock forage from scenarios for such sites.

Agriculture pathways could be eliminated in short-term scenarios if the soil is outright toxic or inhospitable to plants. As examples, (1) no agriculture is apt to occur on the bed of a dry salt lake, and (2) crops are not apt to be grown in made land that contains such a high percentage of concrete materials that extraordinary efforts would be required to maintain the soil pH in a range that is tolerated by plants.

If it can be documented that the soil at this site would not support the resident farmer's agricultural efforts, this pathway should be eliminated or modified.

Documentation to be Submitted to NRC

Soil Unsuitable for Agriculture: NRCS (SCS) or independent consultant report that shows quality of soil is poorer than the standards listed for this use.

M.5.2.2.2 Is Topography Suitable for Agriculture?

In the past few hundred years, the Dutch built dikes and converted shoals into productive farmlands. Today, explosives and earth-moving equipment can easily change features of the landscape, making them suitable for agricultural or residential use. Consequently, locality or

accessability may form a basis for eliminating certain agricultural pathways from scenarios in the next century, but not for a period of 1000 years.

Ignoring the fact that topography may change with time as a result of civil engineering projects, there are probable limits to the types of terrain where mechanized agriculture can be used. Tractors may likely always be unstable on slopes, so there may probably always be a practical limit on the slopes that can be put under mechanized agriculture. In the absence of mechanized agriculture, persons are more likely to practice gardening than to grow commodity food items. They are also more likely to allow livestock to forage than to grow fodder crops.

While there is no predictable maximum safe slope that tractors may traverse without the danger of rollover, operating a tractor on a 30 degree (2 to 1) slope is so hazardous that the average member of the critical group is not likely to attempt it.

If the topography at the site is too steep or too erratic to support the type of farming expected within the resident farmer scenario, the agricultural pathway should be removed or modified in accordance with this finding. There may also be aspects of the topography that would limit farming or other specific activities at the site.

Documentation to be Submitted to NRC

Topography Unsuitable for Agriculture: USGS or similar topographic map, hand-drawn map, or description that provides enough detail to illustrate the topography that limits farming at this site.

M.6 Summary

The process presented in this document is an extension of the Decommissioning Framework. It uses a logical step-by-step procedure for introducing site-specific information to develop alternate scenarios by eliminating pathways from the default resident farmer scenario. As the process schematic leads the licensee through the steps that are required to remove pathways, iterative dose assessments assure that no more information than is necessary should be assembled and analyzed for this purpose. Once the TEDE to an average member of the critical group drops below 0.25 mSv/y (25 mrem/y), the process is completed and the licensee may proceed to license termination. Following the initial dose assessment and each of the iterative dose assessments, sensitivity analyses help the licensee focus on the introduction of evidence that can rule out those pathways that are responsible for the high dose.

Physical and cultural information are introduced to answer a series of questions about the site. The future use of the land may be key to what assumptions the licensee can make about the starting scenario. Information on current land use, past land use, and a history of land use changes can be used to determine the probable future use of the land. If the future land use can reasonably be predicted to be either urban or industrial, the resident farmer scenario can be

bypassed, allowing the licensee to concentrate on these two land uses. If the TEDE to an average member of the critical group persists at a dose above 0.25 mSv/y (25 mrem/y) for a period longer than 100 years, future land use cannot be predicted and the licensee would start with the resident farmer scenario.

The residential farmer scenario is meant to be applied to sites with land and water residual radioactivity and the building occupancy scenario is to be applied to sites with contaminated structures. If a resident farmer scenario is assumed, the most important aspect of the physical nature of the site is the nature and availability of water. The answers to each of four critical questions about water at the site can be used to determine if major pathways can be removed from the scenario. If ground water is not available, all of the pathways that rely on ground water as a key component can be removed: irrigation, aquatic, and drinking. If ground water is not suitable for aquatic life, the aquatic pathway can be removed. If ground water is not suitable for agriculture, irrigation and drinking water pathways can be removed. If the water is not potable, the drinking water pathway can be removed. Detailed discussion is presented to help the licensee answer these questions, to understand the standards that would have to be met for this pathway to be ruled out, and the documentation that would have to be presented to the NRC.

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V INTENTIONAL MIXING OF CONTAMINATED SOIL

The License Termination Rule Analysis of the Use of Intentional Mixing of Contaminated Soil, SECY-04-0035 (NRC 2004), discussed options for the use of intentional mixing. Commission direction was provided in the Staff Requirements Memorandum, SRM-SECY-04-0035. To develop implementing guidance, the NRC staff proposed the following changes to NUREG-1757, Vol. 1, Rev. 1:

- Section 17.1.3, "Soil"

  The staff added a reference to the new Section 15.13 of Vol. 1, Rev. 1, and the addition is shown as highlighted text.

- New Section 15.13, "Use of Intentional Mixing of Contaminated Soil"

  The attached draft guidance provides detailed guidance on intentional mixing. The version included here is intended as a complete new section, so the text is not highlighted.

Changes to NUREG-1757, Vol. 1, Rev. 1, Section 17.1.3, “Soil”

17.1.3 SOIL

The purpose of the review of the description of the planned decommissioning activities for soil is to allow the staff to fully understand what methods and procedures the licensee will undertake to remove or remediate the surface and subsurface soil at the site. This will allow the staff to evaluate the licensee's methods and procedures to qualitatively assess if they can be performed safely and in compliance with NRC requirements. This information may also aid the staff in evaluating the estimates of radioactive waste that will be generated during decommissioning, the cost estimates for the decommissioning, and the ALARA evaluations developed by the licensee to support the decommissioning. Additional guidance on the use of intentional mixing of soil to remediate surface and subsurface soil at the site is provided in Section 15.13.

ACCEPTANCE CRITERIA

Regulatory Requirements

10 CFR 30.36(g), 40.42(g), and 70.38(g)

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to fully understand what methods, procedures, and techniques the licensee intends to use to remove or remediate contaminated soil at the site. In addition, the information should be sufficient to allow the staff to determine if the licensee's radiation safety procedures are appropriate, given the level of contamination in the soil and proposed method(s) for removal or remediation. The staff's review should verify that the following information is included in the description of soil decommissioning activities in the facility DP:

- a summary of the removal/remediation tasks planned for surface and subsurface soil at the site in the order in which they will occur, including which activities will be conducted by licensee staff and which will be performed by a contractor;
- a description of the techniques that will be employed to remove or remediate surface and subsurface soil at the site;
- a description of the radiation protection methods (such as PPE, or area exit monitoring) and control procedures (such as the use of HEPA vented enclosures during excavation or covering soil piles to prevent wind dispersion) that will be employed during soil removal/remediation (The staff's technical review of the adequacy of the licensee's radiation safety procedures should be performed pursuant to the criteria in Section 17.3 of this NUREG. In this section, the staff should make a qualitative assessment of the adequacy of the radiation protection and control methods proposed by the licensee to determine if the procedures described in the Radiation Safety and Health section of the DP have been followed.);

- a summary of the procedures already authorized under the existing license and those for which approval is being requested in the DP;
- a commitment to conduct decommissioning activities in accordance with written, approved procedures;
- a summary of any unique safety or removal/remediation issues associated with remediating the soil; and
- for Part 70 licensees, a summary of how the licensee will ensure that the risks addressed in the facility's Integrated Safety Analysis will be addressed during decommissioning.

EVALUATION FINDINGS

Evaluation Criteria

The staff's review should verify that the licensee has described the remediation activities and associated safety precautions in sufficient detail to allow the staff to determine if the proposed activities can be conducted safely and in compliance with NRC requirements. The staff should verify that the information summarized under "Information to be Submitted," above, is included in the licensee's description of the decommissioning activities portion of the DP. The staff should make a qualitative assessment of the adequacy of the licensee's proposed remediation methods and procedures to accomplish the remediation objectives in a manner that is protective of workers and the public and in compliance with NRC requirements. Detailed technical review of the safety precautions and procedures should be conducted pursuant to the criteria in Section 17.3 of this volume.

Sample Evaluation Findings

None required. The staff should combine the evaluation finding for the licensee's description of decommissioning activities for soil with the findings for the remaining areas in this NUREG volume (see Section 17.1.1).

New to NUREG-1757, Vol. 1, Rev. 1, Section 15.13, "Use of Intentional Mixing of Contaminated Soil"

15.13 USE OF INTENTIONAL MIXING OF CONTAMINATED SOIL

15.13.1 INTRODUCTION

As part of the license termination rule (LTR) analysis, NRC staff examined the use of intentional mixing of contaminated soil to meet the LTR release criteria as an option to provide flexibility in achieving the goals of the LTR. The results of the staff's analysis of this issue are in SECY-04-0035 (NRC 2004). The staff analyzed the possible ways that a licensee could intentionally mix soil to lower its concentration and identified which of these scenarios should be considered further in the analysis. Using these scenarios, the staff evaluated options for allowing intentional mixing[5]. The analysis considered a wide range of relevant information and experience from the NRC and other domestic and international sources.

The Commission approved the use of intentional mixing of contaminated soil to meet the LTR release criteria, in limited circumstances, on a case-by case basis, while continuing the current practice of allowing intentional mixing for meeting waste acceptance criteria (WAC) of offsite disposal facilities and for limited onsite waste disposals at operating facilities (approved under 10 CFR 20.2002).

Intentional mixing has been approved by the NRC staff where homogenous waste streams (for example, soil from two areas of a facility contaminated by similar waste from two different processes) have been mixed to meet the WAC of a disposal facility, as long as the classification of the waste as determined by the requirements of 10 CFR 61.55 is not altered. NRC staff will continue to consider proposals from decommissioning sites for intentionally mixing contaminated soil (and other homogeneous waste streams) to meet WAC of offsite disposal facilities to facilitate completion of remedial actions at sites undergoing license termination.

Intentional mixing has also been approved by the NRC staff for limited onsite disposals approved under 10 CFR 20.2002. A site undergoing decommissioning will normally not seek approval under 10 CFR 20.2002 for an onsite burial (although a Section 20.2002 process may be used to achieve disposal at an offsite location). Licensees should be aware that if intentional mixing is approved for a 10 CFR 20.2002 disposal during operations, that the onsite disposal may need to be readdressed at the time of license termination (see guidance in Section 15.12) to ensure that the dose criteria of the LTR are met.

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[5] NRC staff recognizes that some incidental mixing of contaminated soil and non-contaminated soil may occur as a result of excavation and other earth-moving activities. This mixing that occurs from the use of excavating and earth-moving equipment in normal activities associated with site decommissioning is not considered "intentional" mixing for the purposes of this guidance.

This guidance implements the Commission's policy decisions on the use of intentional mixing of contaminated soil and other homogeneous waste streams from decommissioning sites to meet WAC of offsite disposal facilities and for intentional mixing of soil that remains at the decommissioning site to meet the LTR release criteria.

15.13.2 REVIEW PROCEDURES

The NRC staff will consider proposals to use intentional mixing of contaminated soil (or other homogeneous waste streams) to meet the WAC of an offsite disposal facility to facilitate completion of decommissioning. Licensees should be aware that local and/or State requirements may also apply to waste that is transported to a disposal facility away from the decommissioning site, and that these requirements will have to be met. Approval of a process for a waste stream by the NRC does not imply approval for disposal by the local or State regulators with jurisdiction over the disposal facility. Decisions on approving the use of intentional mixing to meet the WAC of an offsite disposal facility will be performance-based using the appropriate criteria of 10 CFR Part 20, or other Parts of 10 CFR if they apply.

The NRC staff will consider the use of intentional mixing of soil to meet the LTR release criteria (i.e., where the mixed soil will be left on the site) only in cases in which an "overall approach" to site cleanup is proposed that includes soil mixing and ALARA. Proposals to use intentional mixing should be part of an overall plan for decontamination and decommissioning (presented in a DP or LTP) of a licensee's property in which removal and disposal of contaminated components and equipment, decontamination (and demolition, if appropriate) of buildings, removal and disposal of waste streams remaining onsite from past operations, and excavation and removal of large areas of soil contamination as waste, in a systematic fashion that seeks to achieve unrestricted release of the site and renders doses as low as is reasonably achievable.[6] Intentional mixing should not be proposed as a sole remedy, for example, to achieve the LTR release criteria using minimal funds, unless this is the only solution to achieving the license termination dose criteria.

The NRC staff will consider only cases in which this overall approach to site cleanup demonstrates that the removal of soil would not be reasonably achievable. The NRC will consider the same criteria used to determine the eligibility of a site for restricted release [See 10 CFR 20.1403(e)(2)(i)] for determining when removal of soil is not reasonably achievable (i.e., a demonstration that further removal of contaminated soil is not technically achievable, is

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[6] The NRC's staff preferred option for decommissioning is to achieve license termination for unrestricted use of sites where possible. Intentional mixing may be used to achieve the restricted or alternate release criteria. NRC may also consider remedies that include intentional mixing of contaminated soil to achieve unrestricted release of a site, when other remedies alone would result in restricted release. (For example, NRC staff could consider intentional mixing that uses additional uncontaminated soil from outside the footprint if it will achieve unrestricted release).

prohibitively expensive, or when removal would result in net public or environmental harm). Licensees also should include other considerations (e.g., distance to disposal facility, efficient utilization of available disposal capacity at the offsite facility, unavailability of required treatment options, lack of disposal options other than leaving the contaminated soil onsite, and the need to use funds for remediation of non-radioactive hazards at the same site) in proposals for use of intentional mixing, if they are applicable and appropriate to a determination of whether the removal of soil for offsite disposal is reasonable.

Decisions on approving the use of intentional mixing of contaminated soil to meet the LTR will be performance-based using the dose criteria of the LTR. Therefore, licensees have flexibility in how intentional mixing may be used together with other remediation activities to achieve the dose criteria. In addition, staff will base the approval decisions using a risk-informed approach. Licensees should include all relevant information in a proposal to use intentional mixing of soil concerning the risks of using the approach versus other remediation alternatives.

15.13.3 ACCEPTANCE CRITERIA

Information to be Submitted

The information supplied by the licensee should be sufficient to allow the staff to determine that the information adequately describes how the intentional mixing operation will be carried out and that the conditions for approving the use of intentional mixing have been met. In the case where intentional mixing will be used to meet the LTR criteria, the information supplied by the licensee should be sufficient to allow the staff to determine that the limited circumstances for which mixing will be considered are present.

Intentional Mixing to Meet Waste Acceptance Criteria

The staff's review should verify that the following information is included in the sections of the DP corresponding to the sections of the Consolidated Guidance (indicated in parentheses) for decommissioning sites proposing to use intentional mixing to meet the WAC of an offsite disposal facility:

- Information on the intentional mixing activities to be conducted by the licensee or contractors, including the machinery to be used and the methods to be employed with the equipment to achieve a homogeneous mix of soil. Information should be included on important features and parameters of machinery operation that control the homogeneity of the resultant mix, such as mixing time, discharge time, number of mixing blades or paddles, and the maximum particle size. (Section 17.1.3)
- Information on any slag or other larger non-soil like waste materials that will be included in the soil that is intentionally mixed, and how it will be rendered compatible with the mixing machinery (e.g., maximum particle size), if necessary. Information should also be included on

non-soil like waste materials that are included in the mixed soil but which are not compatible with the mixing machinery and how it is compatible with the WAC of the disposal facility. (Section 17.1.3)

- Information on the method to be used to ensure that the mixing operation has resulted in a sufficiently homogeneous mixture to achieve the requirements of the disposal facility. This should include any instrumentation that may be used in support of the machinery used for mixing, as well as any proposed surveying and/or sampling and analysis that is employed. (Sections 17.1.3 and 17.3.1.7)
- Information on how soil following intentional mixing is controlled (e.g., temporary storage) in accordance with the licensee's program for management of volumetrically contaminated materials to ensure it maintains its required properties, if appropriate. (Section 17.5.1)
- Information on how the soil following the intentional mixing operation will meet the Waste Acceptance Criteria of the disposal facility. (Section 17.5.1)

Intentional Mixing to Meet the License Termination Rule

The staff's review should verify that the following information is included in the sections of the DP corresponding to the sections of the Consolidated Guidance (indicated in parentheses) for sites proposing to use intentional mixing to meet the release criteria of the LTR:

- A summary discussion of the overall decommissioning of the site that includes the use of intentional mixing in a comprehensive cleanup approach, including how the licensee will complete interrelated decommissioning activities and the timeframes for completing the activities. This discussion should describe how the intentional mixing proposed helps achieve the goal of unrestricted release, how it is risk-informed, and the reasons that removal of all contaminated soil is not reasonably achievable. (Section 17.1)
- Information on the locations of surface and subsurface contamination that define the areas of contamination for which intentional mixing will be utilized. (Section 16.4.3 and 16.4.4)
- Information on the configuration of the "footprint" of the areas of contamination prior to the mixing operation, and the final area comprised of the intentionally mixed soil. (Section 17.1.3)
- Information on any locations of uncontaminated surface or subsurface soil that will be incorporated into the footprint. (Sections 16.4.3 and 16.4.4)
- Information on the intentional mixing activities to be conducted by the licensee or contractors, including the machinery to be used and the methods to be employed with the equipment to achieve a homogeneous mix of soil. Information should be included on important features and parameters of machinery operation that control the homogeneity of the resultant mix, such as mixing time, discharge time, number of mixing blades or paddles, and the maximum particle size. (Section 17.1.3)

- Information on any slag or other larger non-soil like waste materials that will be included in the soil that is intentionally mixed, and how it will be rendered compatible with the mixing machinery (e.g., maximum particle size), if necessary. Information should also be included on non-soil like waste materials that are included in the mixed soil but which are not compatible with the mixing machinery and how it contributes to the overall plan for decommissioning. (Section 17.1.3)
- Information on the method to be used to ensure that the mixing operation has resulted in a sufficiently homogeneous mixture to achieve the goals of the decommissioning project. This should include any instrumentation that may be used in support of the machinery used for mixing, as well as any proposed surveying and/or sampling and analysis that is employed. (Sections 17.1.3 and 17.3.1.7)
- Information on the final configuration and design attributes of the area containing the intentionally mixed soil, including a soil cap if it is employed. (Section 17.1.3)
- Results of and information that contributes to the ALARA analysis relating to the use of intentional mixing, and meeting the eligibility criteria in 10 CFR 20.1403 (that is used for restricted release determinations). (Section 17.4.1)
- Information on how soil following intentional mixing is controlled (e.g., temporary storage) in accordance with the licensee's program for management of volumetrically contaminated materials to ensure it maintains its required properties, if appropriate. (Section 17.5.1)
- If intentional mixing is used to meet the restricted release criteria, information on advice from affected parties concerning the use of intentional mixing as part of the remediation of a site. (See Section 17.7 on seeking advice from affected parties under 10 CFR 20.1403.) (Section 17.8)

15.3.4 EVALUATION FINDINGS

Approval Conditions

The NRC staff will consider approval of proposals to use intentional mixing from decommissioning sites to meet the WAC of offsite disposal facilities in which the mixture is comprised of soil or other homogeneous waste streams, and does not result in lowering the classification of the wastes (in accordance with 10 CFR 61.55). Proposals to use mixing to meet WAC of an offsite disposal facility should not use clean soil or non-contaminated materials similar to the waste stream to lower the concentrations of a mixture.

NRC staff will consider approval of proposals to use intentional mixing to meet the release criteria of the LTR for soils left on the site in which:

1. The area containing the mixed contaminated soil after license termination is equal to or smaller than the footprint of the zones of contamination before decommissioning begins.

2. Clean soil, from outside the footprint of the area containing the contaminated soil, should not be mixed with contaminated soil to lower concentrations. Staff will consider rare cases where the only viable alternative to achieving the dose levels of the LTR appears to be using clean soil from outside the footprint of the area containing contaminated soil.

Proposals to use intentional mixing of soil to meet the LTR criteria will be approved only if the area of land containing the intentionally mixed soil following remediation activities is no larger than the total of the areas of contaminated soil before remedial actions began. It is reasonable to include some portions of uncontaminated land within the footprint of contaminated areas, where an area encompassing several "zones" of contamination is designated as the footprint to be mixed. To include them, however, the uncontaminated areas should be small in comparison to the areas that are contaminated.

The NRC staff analysis of the use of intentional mixing contemplated circumstances where a contaminated soil was mixed with a contaminated soil of lower concentrations to achieve a mixture that allowed the dose criteria of the LTR to be met. The use of clean soil to achieve the goals of intentional mixing should be limited to the circumstances just described. Any uncontaminated soil that is utilized in the mixing operation should normally be included within the footprint of the contaminated zones that are to be mixed. Staff will consider the inclusion of uncontaminated soil that comes from outside of the footprint of the contaminated zones only in rare cases where its use represents the only reasonable alternative to meeting the release criteria of Part 20, Subpart E. Soil from outside of the site boundary or from an offsite location should not be used for an intentional mixing proposal.

The staff will also consider the inclusion of uncontaminated soil that comes from below the contaminated zones within the footprint as long as it is consistent with the overall approach described for achieving license termination, and considers the impacts associated with an increased depth of disposal (e.g., affect on groundwater).

The staff will consider the inclusion of a limited volume of non-soil materials (e.g., slag or concrete rubble) within the mixed soil as part of remediation as long as analysis is presented demonstrating that the release criteria of the LTR are met, and that inclusion in the mixed soil is consistent with the overall approach to site cleanup in the DP or LTP. In order to be consistent with the overall approach, the non-soil materials to be included in the mixed soil should be incidental to the excavation and removal of buildings, equipment, and major waste streams to be

managed at the decommissioning site.[7] Intentionally mixing a significant non-soil like waste stream resulting from the activities that were conducted at the site during operations (e.g., slag) that is easily removed from the site (e.g., in a pile on the soil surface) should not be included in a proposal for intentional mixing to meet the LTR release criteria.

Evaluation Criteria

The staff should verify that the information summarized under "Information to be Submitted," above, is included in the licensee's descriptions of the surface and subsurface soil contamination, the soil decommissioning activities, instrumentation, control of contaminated material, ALARA evaluation, and stakeholder involvement (if necessary). The staff should verify that intentional mixing of contaminated soil is part of an overall approach to site remediation in which it is demonstrated that removal of the soil to be mixed is not reasonably achievable. The staff should verify that the descriptions of the mixing operation, the use of machinery, and the methodology for ensuring that the mixture is homogeneous are sufficiently detailed to allow the staff to understand the manner in which the licensee will ensure that the expected properties of the mixed soil have been achieved. The staff should ensure that the area containing mixed soil is no greater than the footprint of contaminated areas defined at the start of remediation. The staff should also ensure that uncontaminated soil is not used from outside the site, and the use of uncontaminated soil as part of the defined footprint is minimized. The staff should ensure that any operation to mix contaminated soil to meet Waste Acceptance Criteria of an offsite disposal facility does not result in lowering the classification of the waste in accordance with 10 CFR 61.56.

Sample Evaluation Findings

None required. The staff should combine the assessment of a DP proposing the use of intentional mixing with the findings on the Sections corresponding to the sections in parentheses above.

REFERENCES

- NRC 2004. SECY-04-0035, "Results of the License Termination Rule Analysis of the Use of Intentional Mixing of Contaminated Soil," March 1, 2004.

[7] Staff would consider non-soil materials to be incidental if, for example, a few pieces of small equipment, building rubble, or non-soil waste (e.g., slag) were discovered that required disposal following completion of waste shipping campaigns, or where a waste were most effectively managed (e.g., to avoid a technical difficulty that would increase worker dose), if it were included in the mixed soil.

VI REMOVAL OF MATERIAL AFTER LICENSE TERMINATION

The License Termination Rule (LTR) Analysis, SECY-03-0069 (NRC 2003), included discussion of the relationship between the LTR and the case-by-case approach for releases of solid materials from sites. Following the LTR Analysis, the associated Regulatory Issue Summary (RIS) 2004-08 (NRC 2004) also provided a discussion of the issue. As a result of those two documents, the NRC staff discussed how the conservatism in the LTR Analysis related to offsite removal of material after license termination and how to reduce some of the conservatism and still retain adequate assurance of protection of public health and safety with the unrestricted use of the material. The NRC staff proposes including that discussion in Vol. 2, Appendix I, Section I.3, which is included in Chapter IV of this draft.

As a result of the LTR Analysis, the associated RIS, and NRC staff experience with specific cases, NRC staff revised the following sections of NUREG-1757, Vols. 1 and 2:

- Section G.1.1, “Structures Versus Equipment”

  Section G.1.1 of Vol. 2 includes substantive revisions, which are intended to clarify the guidance. A brief “Background” section was added. The section on implementation is a revision of the previous Section G.1.1. The staff revised the guidance on what building structure-related materials may be left onsite at license termination to better describe approaches preferred by the NRC staff. New text is shown highlighted, and deleted text is shown as strikeout text.

- Section G.3, “References”

  Section G.3 was revised to reflect the new references in Section G.1.1.

- New Section 15.11.1, “Current NRC Approach to Releases of Solid Material”

  New Section 15.11.1 of Vol. 1, Rev. 1, provides more information about the current approaches to releases of solid materials. This guidance is completely new text, to be inserted into Section 15.11 of Vol. 1, Rev. 1, as the first subsection (Section 15.11.1). The existing subsections in Section 15.11 of Vol. 1, Rev. 1, will follow this new guidance and will be renumbered accordingly. The guidance included here is intended as a new subsection, so new text is not highlighted.

Changes to
NUREG-1757, Vol. 2, Appendix G,
Section G.1.1, “Structures Versus Equipment”

G.1.1 Structures Versus Equipment

Background

The NRC staff acknowledges that the relationship between the license termination rule (LTR) for unrestricted use of a site [dose criteria of 0.25 mSv/y (25 mrem/y) and ALARA], and existing guidance for unrestricted releases of solid materials from a site on a case-by-case basis may have been unclear. In particular, the criteria for the LTR and for releases of solid materials prior to license termination are different. Consistent with the LTR, once a site meets the radiological criteria for unrestricted use [0.25 mSv/y (25 mrem/y) plus ALARA] and the NRC terminates the license, solid material may be removed from a site. However, before license termination, material cannot be removed from the site for unrestricted use unless it meets either (a) criteria already approved for the licensed facility (e.g., in a license condition), for surficially contaminated materials; or (b) the few mrem/y criterion for the case-by-case approach for volumetrically contaminated materials. One rationale for the difference in criteria is that the technical basis for the LTR assumed that individuals are generally exposed to residual radioactivity at a single location (the site), while for releases of solid material, an individual may be exposed to materials through several scenarios at offsite locations (NRC 2003). For more information about the relationship between the LTR and the case-by-case approaches to release of solid materials from a site, see the LTR Analysis Commission Paper SECY-03-0069 (NRC 2003) and the associated Regulatory Issue Summary (NRC 2004).

This section focuses on compliance with the LTR, in particular what building structure-related materials may be left onsite at license termination, and what criteria should apply. For more information about current approaches to releases of solid material before license termination, see Section 15.11.1 of NUREG-1757, Vol. 1.

Implementation

The license termination rule (LTR) applies to buildings~~s and~~ structures that remain in place after decommissioning and does not apply to ~~disposition~~ releases of equipment from the facility before license termination. ~~In addition, licensees should note that if they~~ If licensees elect to dismantle buildings~~s and~~ structures and dispose of the associated materials offsite (in accordance with applicable regulatory requirements), rather then leave the buildings~~s and~~ structures in place (for unrestricted use), the LTR does not apply to the associated materials moved offsite prior to license termination. Materials licensees may release equipment and building ~~and~~ structure deconstruction and dismantlement materials in accordance with existing license conditions. Reactor licensees (10 CFR Part 50 licensees) may release equipment and building ~~and~~ structure deconstruction and dismantlement materials in accordance with the guidance in Inspection and Enforcement Circular 81–07, Information Notice 85–92, and Information Notice 88–22. Licensees should refer to Section 15.11 from Volume 1 of this NUREG report and should consult with NRC staff for further guidance on equipment and solid material releases.

~~Examples of parts of buildings or structures that may be covered by the LTR, if allowed to remain onsite, include floors, walls, ceilings, beams, doors, windows, sinks, lighting fixtures, utility lines (i.e., electricity, gas, fuel oil, and water—all supplied by offsite utilities), built-in laboratory hoods and benches, and other types of built-in furniture. Equipment includes anything not attached to or that is not an integral part of the building or structure. Examples of equipment include furniture or appliances that are not built into or attached to the structure; stocks of chemicals, reagents, metals, and other supplies; other materials likely to be removed from the structure and sold for scrap (recycled) or reused; motor vehicles; and any other items that would not normally be conveyed with a building when it is sold.~~

When the LTR was developed, it was assumed that decommissioning generally would include the removal of systems and components from onsite buildings prior to license termination. However, with experience, it has become clear that each licensee uses a different approach for decommissioning, and these approaches are not necessarily consistent with the original assumptions of the LTR. Differences are the result of factors such as: (1) the potential for re-use of systems and components; (2) cost of recycling/price of scrap metal and concrete; and (3) cost and availability of disposal options.

It is clear from the LTR Technical Basis, provided in the Generic Environmental Impact Statement (NRC 1997), and NRC draft Regulatory Guide DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination," dated July 1998, that the LTR was not intended to apply to releases of "equipment" from the facility. "Equipment" includes anything *not attached to*, or not an integral part of, the building structure. On the other hand, the previous guidance (the previous version of this section of NUREG-1757, Vol. 2, 2003) was not prescriptive enough to provide a definitive answer about whether systems and components must be considered "building structures" or "equipment." The previous guidance considered "doors, windows, sinks, lighting fixtures, utility lines, built-in laboratory hoods and benches and other types of built-in furniture" to be part of the structure. Under that guidance, those items could be included in the Final Status Survey (FSS) and left in place at license termination. It could be argued that, based on the examples provided, many plant systems and components also could be considered "building structures," and, therefore, left in place at license termination. This previous guidance may have been inconsistent with the discussion in the LTR Analysis Commission Paper SECY-03-0069 (NRC 2003), which described an expectation that removable materials and equipment would generally not be present at the time of license termination.

In order to clarify for licensees and the NRC staff what building structure-related materials may be left onsite at the time of license termination, and what criteria should be applied to those materials, the staff has identified a number of acceptable approaches.

For this discussion only, NRC staff uses the following descriptions of building structures, systems and components, and equipment:

- "Building structures" include floors, walls, and roofs; components embedded in floors, walls, and roofs (e.g., embedded piping); and items that are attached to and are an integral part of the buildings (e.g., doors and windows).
- "Systems and components" include items attached to a building structure that are not an integral part of the building, but provide important functions to the building (e.g., utility lines, sinks, lighting fixtures, built-in laboratory hoods and benches, polar cranes (in power reactors), and major process equipment).
- "Equipment" includes items not attached to the building structure, that are generally readily removable from the building. Examples of equipment include furniture or 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 normally would not be conveyed with a building when it is sold.

Building Structures, and Systems and Components that May Be Left in Place at License Termination

The NRC staff finds the following three approaches acceptable to determine what materials may be left in buildings at license termination. Licensees also may propose alternative approaches, which the staff will review on a case-by-case basis. Before submitting such alternative approaches, licensees should consult with the NRC staff.

1. **Materials Left Onsite Meet Previously Approved Release Criteria**—Building structures and systems and components may be left in place if residual radioactivity in all materials is within the licensee's previously approved criteria for releases of solid materials for unrestricted use. Such criteria may have been approved in license conditions, technical specifications, or generic NRC guidance. The criteria could include use of the "no-detect" policy for reactor licensees, or policy FC-83-23 (or Regulatory Guide 1.86) for materials licensees (see also NUREG-1757, Vol. 1, Section 15.11 for more information about the current approaches to releases of solid materials).

2. **Materials Left Onsite Meet "Few Millirem per Year"**—Building structures and systems and components may be left in place if residual radioactivity in all materials is volumetrically distributed (not surficial) and if the potential dose from offsite use scenarios is no greater than a few hundredths mSv per year (few mrem per year).

3. **Materials Left Onsite Meet 0.25 mSv/y (25 mrem/y)**—Building structures may be left in place if the potential dose from the residual radioactivity is within the dose criteria of the LTR (i.e., for unrestricted use, no greater than 0.25 mSv/y (25 mrem/y) and ALARA).

For all three approaches, the residual radioactivity in building structures, systems and components, and all other media at the site (e.g., soils or ground water) must be in compliance

with the criteria of the LTR (i.e., for unrestricted use doses must not exceed 0.25 mSv/y (25 mrem/y) and must be ALARA).

For approaches 2 and 3, licensees will perform dose assessments (or use NRC-approved screening dose assessments) to demonstrate compliance with the dose criteria. For the dose assessments under approach 3, when less conservative and more realistic exposure scenarios are selected, these may no longer bound potential off-site use scenarios. Typically, licensees do not evaluate potential off-site future use scenarios, such as removal of soil for fill material or road base or reuse of concrete as road bed material. Thus, the more realistic scenario option also should consider off-site uses (note that the dose criterion is the same 0.25 mSv/y (25 mrem/y) and ALARA for unrestricted use). For additional guidance, see Section I.3.3.3.6 of Appendix I of this Volume.

Equipment Not Covered by the LTR

The LTR does not apply to equipment, so equipment should not be left on the site at license termination. Equipment should be released under the current approaches for releases of solid materials, as discussed in NUREG-1757, Vol. 1, Section 15.11 (or could be disposed as radioactive waste).

Changes to NUREG-1757, Vol. 2, Appendix G, Section G.3, “References”

G.3 References

Nuclear Regulatory Commission (U.S.) (NRC). Inspection and Enforcement Circular No. 81–07, "Control of Radioactively Contaminated Material." NRC: Washington, DC. May 14, 1981.

— — — — —. Information Notice No. 85–92, "Surveys of Wastes Before Disposal from Nuclear Reactor Facilities." NRC: Washington, DC. December 2, 1985.

— — — — —. Information Notice No. 88–22, "Disposal of Sludge from Onsite Sewage Treatment Facilities at Nuclear Power Stations." NRC: Washington, DC. May 12, 1988.

— — — — —. NUREG-1496, "Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities." NRC: Washington, DC. November 1996.

— — — — —. NUREG–1575, Rev. 1, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)." EPA 402–R–97–016, Rev. 1, DOE/EH–0624, Rev. 1. U.S. Department of Defense, U.S. Department of Energy, U.S. Environmental Protection Agency, and NRC: Washington, DC. August 2000.

— — — — —. NUREG–1727, "NMSS Decommissioning Standard Review Plan." NRC: Washington, DC. September 2000.

— — — — —. NUREG/CR–5512, Vol. 1, "Residual Radioactive Contamination From Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent." NRC: Washington, DC. October 1992.

— — — — —. Regulatory Issue Summary 2002–02, "Lessons Learned Related to Recently Submitted Decommissioning Plans and License Termination Plans." NRC: Washington, DC. January 2002.

— — — — —. Regulatory Issue Summary 2004–08, "Results of the License Termination Rule Analysis." NRC: Washington, DC. May 2004.

— — — — —. SECY-03-0069, "Results of the License Termination Rule Analysis." Policy Issue Memorandum from W.D. Travers to the Commissioners. NRC: Washington, DC. May 2, 2003.

New to NUREG-1757, Vol. 1, Rev. 1, Section 15.11.1, "Current NRC Approach to Releases of Solid Material"

15.11.1 Current NRC Approach to Releases of Solid Material

Currently, NRC staff generally addresses the release of solid material on a case-by-case basis using license conditions and existing regulatory guidance. In each case, material may be released from a licensed operation with the understanding and specific acknowledgment that the material may contain very low amounts of radioactivity, but that the concentration of radioactive material is so small that its control through licensing is no longer necessary.

The case-by-case approach includes guidance that is applicable to equipment and material with radioactivity located on the surface or within the material or equipment itself. However, there are differences in the application of this guidance between reactor licensees and materials licensees, which is explained below.

15.11.1.1 Release of Solid Materials with Surface Residual Radioactivity

All Licensees

Criteria which licensees must use in determining whether the material may be released are approved for use by the NRC staff during the initial licensing or license renewal of a facility, as part of the facility's license conditions or radiation safety program. The licensees' actions must be consistent with the requirements of 10 CFR Part 20 (e.g., Subpart F of Part 20 (10 CFR 20.1501)). Thus, the licensee performs a survey of the material prior to its release.

Reactor Licensees

Reactor licensees typically follow a policy that was established by Office of Inspection and Enforcement Circular 81-07 and Information Notice 85-92. Under this approach, reactor licensees must survey equipment and material before its release. If the surveys indicate the presence of AEA material above natural background levels, then no release may occur. If the appropriate surveys have not detected licensable material above natural background levels, the solid material in question does not have to be treated as waste under the requirements of Part 20. The fact that no radioactive material above background is detected does not mean that none is present; there are limitations on detection capability. In practice, the actual detection capability of survey instruments are typically consistent with those contained in Regulatory Guide 1.86.

Materials Licensees

For materials licensees, NRC staff usually authorizes the release of solid material through specific license conditions. One set of criteria that is used to evaluate solid materials before they are released is contained in Regulatory Guide 1.86, entitled "Termination of Operating Licenses for Nuclear Reactors." A similar guidance document is Fuel Cycle Policy and Guidance

Directive FC 83-23, entitled "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Byproduct, Source or Special Nuclear Materials Licenses." Both documents contain a table of surface contamination criteria

which may be applied by licensees for use in demonstrating that solid material with surface contamination can be safely released with no further regulatory control.

Although Regulatory Guide 1.86 was originally developed for nuclear power plant licensees, the surface contamination criteria have been used in other contexts for all types of licensees for many years. By setting maximum allowable limits for surface contamination, Regulatory Guide 1.86 implicitly reflects the fact that materials with surface contamination below those limits may be released without adverse effects on the public health and safety.

15.11.1.2 Release of Solid Materials with Volumetric Residual Radioactivity

In the case of volumetrically contaminated materials, NRC staff has not provided guidance like that found in Reg Guide 1.86 for surface contamination. Instead, NRC staff has treated these situations on an individual basis, typically seeking to assure, by an evaluation of doses associated with the proposed release of the material, that maximum doses are a small percentage of the Part 20 dose limit for members of the public. Thus, the NRC staff practice over the years has been to allow the release of material with slight levels of volumetric contamination based on a case-by-case evaluation. These evaluations follow guidance discussed in the June 1999 Issues Paper (NRC 1999b) and in three All-Agreement States letters (STP-00-070, STP-01-081, STP-03-003), dated August 22, 2000, November 28, 2001, and January 15, 2003, respectively. Licensees have used the process set out in 10 CFR 20.2002 to seek approval for alternate disposal methods of solid material. The release of material using the 10 CFR 20.2002 process is consistent with other disposition provisions in Part 20 that allow for the release of material (e.g., 10 CFR 20.2003 and 10 CFR 20.2005). The current guidance that would be used to evaluate doses associated with 10 CFR 20.2002 requests is NUREG-1757, Volume 2.

Reactor Licensees

For reactor licensees, the release of volumetrically contaminated materials is being implemented under the provisions of Information Notice No. 88-22: Disposal of Sludge from Onsite Sewage Treatment Facilities at Nuclear Power Stations. Certain materials may be surveyed using a representative sample and gamma spectrometry analytical methods. The provision requires that materials can be released if no licensed radioactive material above natural background levels is detected, provided the radiation survey used a detection level that is consistent with the lower limit of detection values used to evaluate environmental samples. NRC guidance states that the lower limit of detection (LLD) to be used for radiation surveys is the "operational state of the art" LLD values given in the Standard Radiological Effluent Technical Specifications (RETS) for

environmental samples taken as part of the licensee's radiological environmental monitoring program.

The environmental LLDs are contained in Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants," and in a Branch Technical Position (NRC 1979). They are also contained in NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," and NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors." There are several different acceptable survey applications of the environmental LLDs and applications have included a variety of environmental media including soils, sediments, liquids and slurries.

Materials Licensees

For materials licensees, the release of volumetrically contaminated materials is being implemented under the provisions of the December 27, 2002, NRC Memorandum, "Update on Case-Specific Licensing Decisions on Controlled Release of Concrete from Licensed Facilities" (referenced in STP-03-003). This memorandum indicates that controlled releases of volumetrically contaminated concrete may be approved, pursuant to 10 CFR 20.2002, under an annual dose criterion of a "few mrem."

VII OTHER ISSUES AND CHANGES

NRC staff believes that several other issues warrant changes to the guidance in NUREG-1757. These other issues were identified through the NRC decommissioning workshop or through staff suggestions. The changes are discussed briefly here, and the proposed updates or additions to NUREG-1757 are included in the following guidance.

- NRC staff identified a need to update NUREG-1757 to refer to the recently issued Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) for guidance on data quality and reporting. The staff revised the following sections of NUREG-1757, Vol. 2:
  - Section 4.0, "Facility Radiation Surveys." NRC staff added a new paragraph to Section 4.0, which is shown highlighted in the following guidance.
  - Appendix D, "Survey Data Quality and Reporting." NRC staff proposes replacing the existing Appendix D with the following version. The version included here is intended as a complete replacement, so highlighting is not used.
  - Appendix E, "Measurements for Facility Radiation Surveys." NRC staff also added appropriate references to MARLAP in Appendix E. The new text is shown highlighted, and deleted text is shown as strikeout text.
- Through work on a specific decommissioning case, NRC staff identified a need to clarify what statistical mean value of measured radionuclide concentrations should be used to calculate the source term for dose assessments. NRC staff revised the language in Vol. 2, Appendix I, Section I.2, "Source-Term Abstraction." The new text is shown highlighted, and deleted text is shown as strikeout text.
- Based on the proposed extensive changes to the guidance on institutional controls and engineered barriers at restricted use sites, the NRC staff felt it important to update the discussions of (1) how the guidance is risk-informed and (2) the flexibility in the regulations and flexibility in demonstrating compliance. These both are addressed in Chapter 2 of Vol. 2.
  - The risk-informed nature of the restricted use guidance is addressed through a proposed addition to Vol. 2, Section 2.1, "Risk-informed Approach to Compliance Demonstrations and Reviews," shown as highlighted text.
  - The flexibility in compliance for restricted use sites is addressed through a proposed new section to Vol. 2, Section 2.8, "Flexibility for Use of Institutional Controls and Engineered Barriers at Restricted Use Sites." The version included here is intended as a complete new section, so new text is not highlighted.
- NRC staff identified that the financial assurance guidance in NUREG-1757, Vol. 3, did not discuss procedures for returning, canceling, or reducing financial assurance instruments. NRC staff added Chapter 8, "Returning, Canceling, or Reducing Financial Assurance Instruments," to Vol. 3 to address this issue. The version included here is intended as a complete new section, so new text is not highlighted.
- NRC revised Vol. 1, Rev. 1, Section 5.2, "Decommissioning Process," to include a Memorandum of Understanding (MOU) between the U.S. Environmental Protection Agency (EPA) and NRC. The EPA/NRC MOU, "Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites" was included in Vol. 1, Rev. 1, in September 2003. The revisions are shown as highlighted text.

Changes to
NUREG-1757, Vol. 2,
Section 4.0, “Facility Radiation Surveys”

4 FACILITY RADIATION SURVEYS

~~The information in this chapter is taken directly from Chapter 14 of the SRP (NUREG–1727). There has been some minor editing, and additional descriptive information has been inserted. Section 4.6, a new section, has been added to discuss specific facility radiation survey issues which are not addressed in MARSSIM. However, the essential information in this chapter is the same as Chapter 14 of the SRP. This chapter is applicable, either in total or in part, to Decommissioning Groups 2–7.~~

RADIATION SURVEY AND SITE INVESTIGATION PROCESS

As a framework for collecting the information required for demonstrating compliance identified using the data quality objectives (DQO) process (see Section 3.2 of this Volume), NRC staff recommends using a series of surveys. The radiation site survey and investigation (RSSI) process is an example of a series of surveys designed to demonstrate compliance with the decommissioning regulations of 10 CFR Part 20, Subpart E. Table 4.1 identifies the steps in the RSSI process and indicates where specific guidance on each step can be found.

Table 4.1 Cross-References for Principal Steps in the Radiation Survey and Site Investigation Process

Principal Step	Applicable Guidance
Site Identification	Chapter 16, Volume 1 of this NUREG report Section 2.4 of MARSSIM
Historical Site Assessment	Section 4.0 of this volume Sections 2.4 and Chapter 3 of MARSSIM
Characterization Survey	Sections 2.4 and 5.3 of MARSSIM Section 4.2 of this volume
Remedial Action Support Survey	Sections 2.4 and 5.4 of MARSSIM Section 4.3 of this volume
Final Status Survey	Sections 2.4 and 5.5 of MARSSIM Section 4.4 of this volume

HISTORICAL SITE ASSESSMENT

The RSSI process uses a graded approach that starts with the Historical Site Assessment (HSA) and is later followed by other surveys that lead to the final status survey (FSS). The HSA is an investigation to collect existing information describing a site's complete history from the start of site activities to the present time. The necessity for detailed information and amount of effort to

conduct an HSA depends on the type of site, associated historical events, regulatory framework, and availability of documented information. The main purpose of the HSA is to determine the current status of the site or facility, but the data collected may also be used to differentiate sites that need further action from those that pose little or no threat to human health and the environment. This screening process can serve to provide a site disposition recommendation or to recommend additional surveys. Because much of the data collected during HSA activities is qualitative or is analytical data of unknown quality, many decisions regarding a site are the result of professional judgment.

The primary objectives of the HSA include the following:

- identify potential sources of residual radioactivity,
- determine whether or not sites pose a threat to human health and the environment,
- differentiate impacted from non-impacted areas,
- provide input to scoping and characterization survey designs,
- provide an assessment of the likelihood of residual radioactivity migration, and
- identify additional potential radiation sites related to the site being investigated.

The HSA typically consists of three phases: (1) identification of a candidate site, (2) preliminary investigation of the facility or site, and (3) site visits or inspections. The HSA is followed by an evaluation of the site based on information collected during the HSA. Additionally, the HSA should identify special survey situations that may need to be addressed such as subsurface radioactivity; sewer systems, waste plumbing, and floor drains; ventilation ducts; and embedded piping containing residual radioactivity. Refer to Appendix G of this volume for information on special survey situations. Additional guidance on the HSA can be found in Section 2.4.2 and Chapter 3 of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

SUMMARY OF SURVEY TYPES

NRC's regulations require a licensee to make or cause to be made surveys that may be necessary for the licensee to comply with the radiological criteria for license termination, Subpart E of 10 CFR Part 20. The licensee would demonstrate compliance with this requirement by performing an FSS. The FSS will demonstrate that the licensee's site or facility, or both meet(s) the radiological criteria for license termination.

Other surveys (e.g., scoping surveys, characterization surveys, and remedial action support surveys) are used for the purpose of locating residual radioactivity, but are not used to demonstrate compliance with the radiological criteria for license termination.

NRC endorses the final status survey methodology described in MARSSIM. The guidance in this chapter does not replace MARSSIM and users of this chapter should be familiar with and use MARSSIM. Thus, it is intended that licensees will use this chapter and MARSSIM as guidance for acceptable approaches or methodologies to conduct remediation surveys and FSSes in particular. The following sections provide references to specific sections of MARSSIM.

The measurement methods applied in assessing radiation and radioactivity levels can vary according to the objectives of the particular survey. It is expected that different types of surveys would be conducted during the course of decommissioning work, with each having different emphasis while at the same time sharing common elements. A brief summary of six survey types is provided below:

Background Survey

Although, not specifically identified as a step in the RSSI process, this survey constitutes measurements of sites in areas surrounding the facility in order to establish the baseline, that is, the normal background levels of radiation and radioactivity. In some situations, historical measurements may be available from surveys performed before the construction and operation of a facility. The background survey takes on added importance if one may ultimately be comparing onsite cleanup units to offsite reference areas. Appendix A of this volume provides guidance on background surveys.

Scoping Survey

This survey, performed to augment the HSA, provides sufficient information for (a) determination if residual radioactivity is present that warrants further evaluation and (b) initial estimates of the level of effort required for remediation and to prepare a plan for a more detailed survey, such as a characterization survey. The scoping survey does not require that all radiological parameters be assessed. Additional guidance on the scoping survey can be found in Sections 2.4 and 5.2 of MARSSIM, and Section 4.2 of this volume.

Characterization Survey

This survey determines the type and extent of residual radioactivity on or in structures, residues, and environmental media. The survey should be sufficiently detailed to provide data for planning decommissioning actions, including remediation techniques, projected schedules, costs, waste volumes, and health and safety considerations during remediation. Additional guidance on characterization surveys can be found in Section 4.2 of this volume.

Remedial Action Support Survey

This monitoring program is conducted in what is effectively a real time mode to guide cleanup efforts and ensure the health and safety of workers and the public. The effectiveness of the remediation efforts as they progress can be assessed. The precision and accuracy of

measurements associated with this type of survey are generally not sufficient to determine the final radiological status of the site. Additional guidance on remedial action support surveys can be found in Section 4.3 of this volume.

Final Status Survey

This survey demonstrates that residual radiological conditions satisfy the predetermined criteria for release for unrestricted use or, where appropriate, for use with designated restrictions. It is this survey that provides data to demonstrate that all radiological parameters (e.g., total surface activity, removable surface activity, exposure rate, and radionuclide concentrations in soil and other materials) satisfy the established guidelines and conditions. Additional guidance on final status surveys (FFSes) can be found in Section 4.4 of this volume.

Confirmatory Survey

This survey is performed by the regulator to provide data to substantiate the results of the licensee's FSS. The objective of this type of survey is to verify that characterization, remediation, and final status actions and documentation, conducted as part of the RSSI process, are adequate to demonstrate that the site is radiologically acceptable, relative to applicable criteria. Section 15.4.5 of Volume 1 of this NUREG report provides additional information on confirmatory surveys.

These types of surveys are performed at various stages of the decommissioning process. Early on, and where known residual radioactivity exists, the simplest of measurement approaches can be used to document the need for a specific building surface or parcel of land to be cleaned up. In practice, the simpler methods would generally be applicable to the scoping and remediation control surveys. The more complex methods which produce data with higher precision and accuracy will be required for background, characterization, final status, and confirmatory surveys. In general, wherever measurements are to be performed at or close to background levels, greater sensitivity in the measurement is required.

The conduct of these surveys and the methods applied have some interchangeable elements. It is possible that measurements collected in one survey can be used for another. For instance, if measurements sufficient in spatial coverage and with adequate detection limits were taken, the results of the scoping survey in an unaffected area could be used to support the FSS. The emphasis of the guidance in this volume is on the methodology that can be applied to meet the requirements of the FSS, although they can be applied to other survey work as well.

In late 2004, NRC released the final version of the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP). MARLAP and MARSSIM are complementary guidance documents in support of cleanup and decommissioning activities. MARSSIM provides guidance on how to plan and carry out a study to demonstrate that a site meets appropriate release criteria. It describes a methodology for planning, conducting, evaluating, and documenting environmental radiation surveys conducted to demonstrate compliance with cleanup criteria. MARLAP

provides guidance and a framework for both project planners and laboratory personnel to ensure that radioanalytical data will meet the needs and requirements of cleanup and decommissioning activities.

MARLAP recommends the use of a directed or systematic planning process. A directed planning process is an approach for setting well-defined, achievable objectives and developing a cost effective, technically sound sampling and analysis design that balances the data user's tolerance for uncertainty in the decision process with the resources available for obtaining data to support a decision. For example, NRC and licensees have determined that side-by-side surveys (with subsequent partial site releases) are more efficient then waiting for a final site-wide confirmatory survey (See Appendix O, lesson 4 on inspections). NRC and licensees should plan ahead and coordinate their schedules in order to implement efficient side-by-side confirmatory surveys. See Appendix D for more details on MARLAP and how it can enhance radiation monitoring.

Refer to Appendix D of this volume for information on survey data quality and reporting, Chapter 5 of MARSSIM for survey checklists, Appendix E for information on survey measurements, and Appendix G for information on special survey issues. Also refer to Appendix O for related information on lessons learned from recently submitted DPs and questions and answers to clarify existing license termination guidance.

AREAS OF REVIEW

NRC staff should review the radiological characterization survey results to determine whether the characterization survey provides sufficient information to permit planning for site remediation that will be effective and will not endanger the remediation workers, to demonstrate that it is unlikely that significant quantities of residual radioactivity have gone undetected, and to provide information that will be used to design the FSS.

NRC staff should review the FSS design to determine whether the survey design is adequate for demonstrating compliance with the radiological criteria for license termination.

NRC staff should review the results of the FSS to determine whether the survey demonstrates that the site, area, or building meets the radiological criteria for license termination.

NRC staff should note that NRC regulations require that DPs include a description of the planned final radiological survey. Recognizing the flexible approach discussed in Section 2.2 of this volume and that the MARSSIM approach allows certain information needed to develop the final radiological survey to be obtained as part of the remedial activities at the site, a licensee or responsible party may submit information on facility radiation surveys in one of two ways, as summarized below. Section 2.2 of this volume provides additional relevant guidance.

- Method 1:
  The licensee or responsible party may submit the information contained in Sections 4.1–4.3 of this volume of this NUREG as part of the DP, along with a commitment to use the MARSSIM approach in developing the final radiological survey. The information discussed in Section 4.4 would then be submitted by the licensee or responsible party at the completion of remediation or when the licensee or responsible party has completed developing the design of the final radiological survey for the site. The final status survey report (FSSR) (Section 4.5) will be submitted after the licensee or responsible party has performed the final radiological survey.
- Method 2:
  The licensee or responsible party may submit the information contained in Sections 4.1–4.4 of this volume along with a commitment to calculate the number of sampling points that will be used in the final radiological survey in accordance with the procedure described in MARSSIM. The FSSR (Section 4.5) would then be submitted after the licensee or responsible party has performed the final radiological survey. If this method is used, the licensee or responsible party should include in the FSSR the information contained in the last three bullets under "Information to be Submitted," in Section 4.4 of this chapter.

Acceptance Review

NRC staff should ensure that the licensee's submittal contains the information summarized under the above "Areas of Review," as appropriate for the particular submittal. NRC staff should review the information submitted to ensure that the level of detail appears to be adequate for the staff to perform a detailed technical review, but NRC staff should not review the technical adequacy of the information. The adequacy of this information should be assessed during the detailed review.

Safety Evaluation

The material to be reviewed is both informational in nature and requires specific detailed technical analysis. NRC staff should verify that the survey designs and results are adequate for demonstrating compliance with the radiological criteria for license termination.

Changes to
NUREG-1757, Vol. 2,
Appendix D, “Survey Data Quality and Reporting”

INTRODUCTION

The Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP, 2004) and the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, 2000) are complementary guidance documents in support of cleanup and decommissioning activities. MARSSIM provides guidance on how to plan and carry out a study to demonstrate that a site meets appropriate release criteria. It describes a methodology for planning, conducting, evaluating, and documenting environmental radiation surveys conducted to demonstrate compliance with cleanup criteria. See Chapter 4 and Appendix A for more details on MARSSIM. MARLAP provides guidance and a framework for both project planners and laboratory personnel to ensure that radioanalytical data will meet the needs and requirements of cleanup and decommissioning activities.

Radioanalytical data are commonly generated to support activities such as: characterization and survey of radiologically contaminated sites, effluent and environmental monitoring of nuclear facilities, emergency response to accidents involving radiological materials, cleanup and decommissioning of nuclear facilities, and radioactive waste management. Numerous significant decisions, impacting the health and safety of the public and the environment, are frequently based on the available radioanalytical data. Considering these activities, the decisions associated with the radioanalytical data may involve issues pertaining to the extent and depth of contamination and associated remedial actions, demonstration of compliance with the cleanup criteria, demonstration of compliance with the effluent release criteria, assessment of effluent radiological releases and corrective measures, assessment of actions in response to incidents or accidental releases of radiological materials, and issues involving waste storage, transport, and disposal. In addition, radioanalytical data commonly influence decisions related to the cost of remedial actions as well as decisions involving environmental monitoring strategies and designs.

MARLAP was developed to provide guidance and framework for project planners, managers, technical reviewers, and laboratory personnel to ensure that the radioanalytical data produced by surveys will meet the needs and requirements for cleanup and decommissioning activities. MARLAP addresses the need for a nationally consistent approach to producing radioanalytical laboratory data that meet a project's or program's data requirements. The guidance provided by MARLAP is both scientifically rigorous and flexible enough to be applied to a diversity of projects and programs. The MARLAP manual (NRC document number NUREG-1576 and U.S. Environmental Protection Agency (EPA) document number EPA 402-B-04-001A-C) is issued in three volumes (printed and CD-ROM versions) and is available through the Internet at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1576.

The NRC staff encourages licensees to follow the recommendations provided in the MARLAP.

D.1 An Overview of MARLAP

MARLAP is divided into two main parts, Part I and Part II. Part I provides guidance on using a performance-based approach for the three phases of radioanalytical projects, including: (1) the planning phase; (2) the implementation phase; and (3) the assessment phase. These three main phases and associated processes should result in analytical data of known quality appropriate for the intended use. Table 1 provides an overview of the three main phases, the processes associated with each phase, and the anticipated outputs for each process. Figure 1 illustrates an overview of MARLAP terms and processes and interactions of the radioanalytical project manager with the laboratory performing the analysis. MARLAP processes and terms described in Table 1 and Figure 1 are consistent with standard practices of the American Society for Testing of materials (ASTM) for generation of environmental data. Chapters 3 through 9 of the MARLAP manual provide a detailed description of MARLAP phases and specific processes. It should be noted that it is not a regulatory requirement to follow or use MARLAP processes as described in Figure 1; however, these processes are believed to be flexible and scientifically rigorous to be applied for generation of radioanalytical data of the desired quality for the intended use.

Part II of MARLAP provides technical information on the laboratory analysis of radionuclides. Specifically, Part II highlights common radioanalytical problems and how to correct them. It also provides options for analytical protocols and discusses the pros and cons of these options. It should be noted that Part II does not provide a step-by-step instructions on how to perform certain laboratory procedures or tasks. However, Part II provides guidance to assist laboratory personnel in selection of the best approach for a particular laboratory task. For example, Chapter 13 does not contain a step-by-step instruction on how to dissolve a soil sample; however, it does provide information on acid digestion, fusion techniques, and microwave digestion, to help the analyst select the most appropriate technique or approach for a particular sample characteristics and project needs. Part II presents detailed technical information in the following areas: (1) field sampling that affect laboratory measurements; (2) sample receipt, inspection, and tracking; (3) laboratory sample preparation; (4) sample dissolution; (5) separation techniques; (6) quantification of radionuclides; (7) data acquisition, reduction, and reporting for nuclear counting instrumentation; (8) waste management in a radioanalytical laboratory; (9) laboratory quality control; (10) measurement uncertainty; and (11) detection and quantification capabilities. MARLAP adopted the International Organization for Standardization (ISO) processes, terms, and expressions for analytical measurements, quantifications, and estimation of uncertainty.

MARLAP also presents additional technical details on specific topics outlined in Parts I and II. Appendices A through E support Part I for the following specific topics: Appendix A, Directed Planning Approaches; Appendix B, The Data Quality Objective Process; Appendix C, Measurement Quality Objectives for Method Uncertainty and Detection; Appendix D, Content of Project Plan Documents; and Appendix E, Contracting Laboratory Services. Appendix F supports Part II for the specific topic on laboratory sub-sampling, whereas Appendix G provides a compilation of statistical tables.

D.2 Use of MARLAP in Decommissioning and Cleanup Projects

MARLAP presents a useful approach and methodology applicable to radionalytical projects for cleanup and decommissioning activities. The major processes of the data life cycle are described briefly below for application in cleanup and decommissioning activities:

D.2.1 The Planning Phase

The directed planning process for cleanup and decommissioning typically involves the following radioanalytical aspects:

- **Stating the cleanup problem**: Identify the analytes of concern, matrix of concern, regulatory requirements, sampling constraints, primary decisions maker, available resources, existing data and its reliability.
- **Identifying the cleanup decision**: Assess different analytical protocols, identify items of the analytical protocols specifications (APS), and determine how sample collection will affect the measurement quality objectives (MQOs).
- **Identifying the inputs to the cleanup decisions:** Define characteristics of the analytes and matrix, assess the concentration range for the analyte of interest, and define action levels.
- **Defining the decision boundaries:** Identify background, temporal and spatial trends of data and determine limitations of current analytical protocols.
- **Developing a decision rule and tolerable decision error rates**: For example the decision rule may be defined as: "If the mean concentration of analyte x in the upper 15 cm of the soil is greater than z Bq/g, then an action would be taken to remove the soil from the site." Estimates of uncertainties in the data considering action levels and/or derived concentration guidelines should be made.
- **Specifying limits on decision error rates:** Evaluate range of possible parameter values and allowable difference between the action level and the actual value.
- **Optimizing the strategy for obtaining data**: This process may involve optimization of the design for data collection through coordination with the different team members. The process also involves development of analytical protocols specifications and establishing performance measures of the MQOs.

D.2.2 The Implementation Phase

The radioanalytical process is a compilation of activities starting from the time a sample is collected and ending with the data reduction and reporting. Figure 2 illustrates the typical components of an analytical process used for radiological characterization and survey of contaminated sites. Certain cleanup or decommissioning projects may not include all of the

components listed in Figure 2. The analytical protocols usually comprise a compilation of specific procedures or methods and are performed in succession depending on the particular analytical process. Using a performance based approach, there will be a number of alternative protocols that might be appropriate for a particular analytical process. A major component of the analytical protocol is the analytical method. The radioanalytical process should also include the analytical uncertainty, the analytical error, the precision, the bias, and the accuracy of the method used.

D.2.3 The Assessment Phase

The assessment phase focuses on three major steps including:

- **Data verification:** This step assures that the laboratory conditions and operations are in compliance with the statement of work (SOW) and the project quality assurance project plan (QAPP). The verification process would examine the laboratory standard operating procedures. It would also check for consistency and comparability of the data, correctness of the data calculations, and completeness of the results and data documentation.
- **Data validation:** This step addresses the reliability aspects of the radioanalytical data. It addresses the analyte and matrix types as well as the uncertainty of the measurement to support the intended use. Validation flags (qualifiers) are typically applied to data that do not meet the acceptance criteria established to meet the project data quality objectives (DQOs) and MQOs.
- **Data quality assessment (DQA):** This step represents the scientific and statistical data evaluation aspects to determine if data are of the right type, quality, and quantity to support the intended use. The DQA is more global in its purview such that it considers the combined impacts of all project activities on data quality and its usability.

D.3 Benefits of Using MARLAP in Decommissioning and Cleanup Projects

MARLAP is an extensive document which presents a comprehensive guidance and information on the three phases of the radioanalytical data life cycle. MARLAP emphasizes the importance of establishing the proper linkages among these phases. Use of MARLAP in decommissioning and cleanup projects can benefit the user in the following aspects:

- MARLAP ensures generation of radioanalytical data of acceptable quality for the intended use.
- MARLAP minimizes time and effort expended in generation of unacceptable data.
- MARLAP enhances public trust in radioanalytical data generated by licensees and regulators.
- MARLAP minimizes efforts applied to justifying data and may limit any litigation costs.

- Because MARLAP uses an early coordinated approach to develop the radioanalytical data DQOs and MQOs, this approach would require early coordination and inputs from the decision makers, the project manager, the shareholders, the concerned team members, and the analyst (see Figure 1). Therefore, this approach should resolve issues or difficulties related to sampling, sample tracking, sample preservation, analysis, data quality, time, and costs early in the process.
- MARLAP provides flexibility in selection of the appropriate analytical method using a performance based approach considering the DQOs, the MQOs, and the available resources.
- MARLAP enhances regulatory reviews of radioanalytical data and saves time and effort for site characterization, environmental monitoring, decommissioning, and remediation.

Table D.1 The Radioanalytical Data Life Cycle

PHASE	PROCESS	PROCESS OUTPUTS
PLANNING	Directed Planning Process	Development of DQOs and MQOs including Optimized Sampling and Analytical Designs
	Plan Documents	Project Plan Documents Including QAPP Work Plan, or Sampling and Analysis Plan (SAP), Data Validation Plan; Data Quality Assessment Plan
	Contracting Services	SOW and Other Contractual Documents
IMPLEMENTATION	Sampling	Laboratory Samples
	Analysis	Laboratory Analysis including QC Samples and Complete Data Package
ASSESSMENT	Verification	Verified Data and Data Verification Report
	Validation	Validated Data and Data Validation Report
	Data Quality Assessment	Assessment Report
Data of Known Quality Appropriate for the Intended Use		

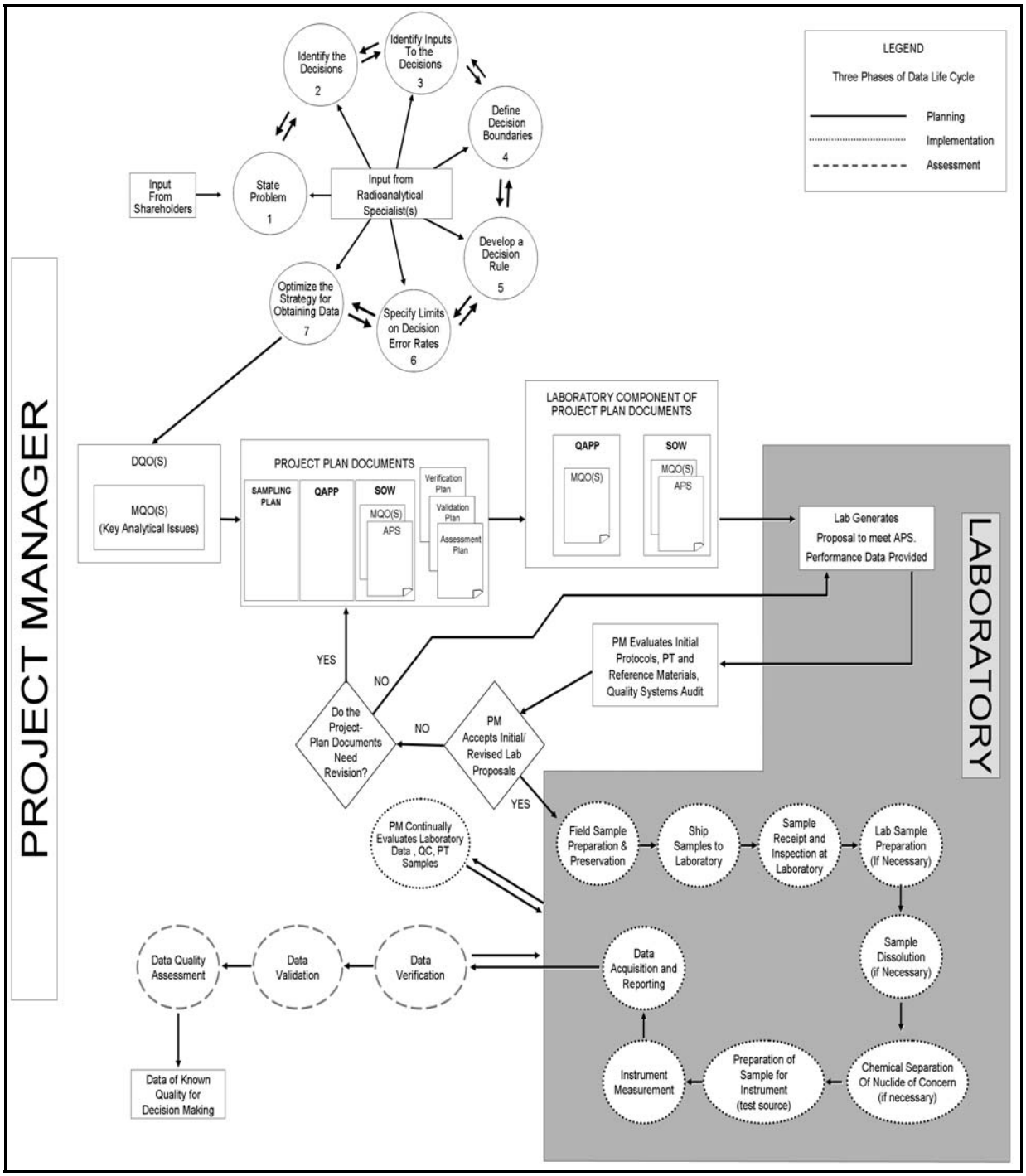

Figure D.1 MARLAP Road Map – Key Terms and Processes

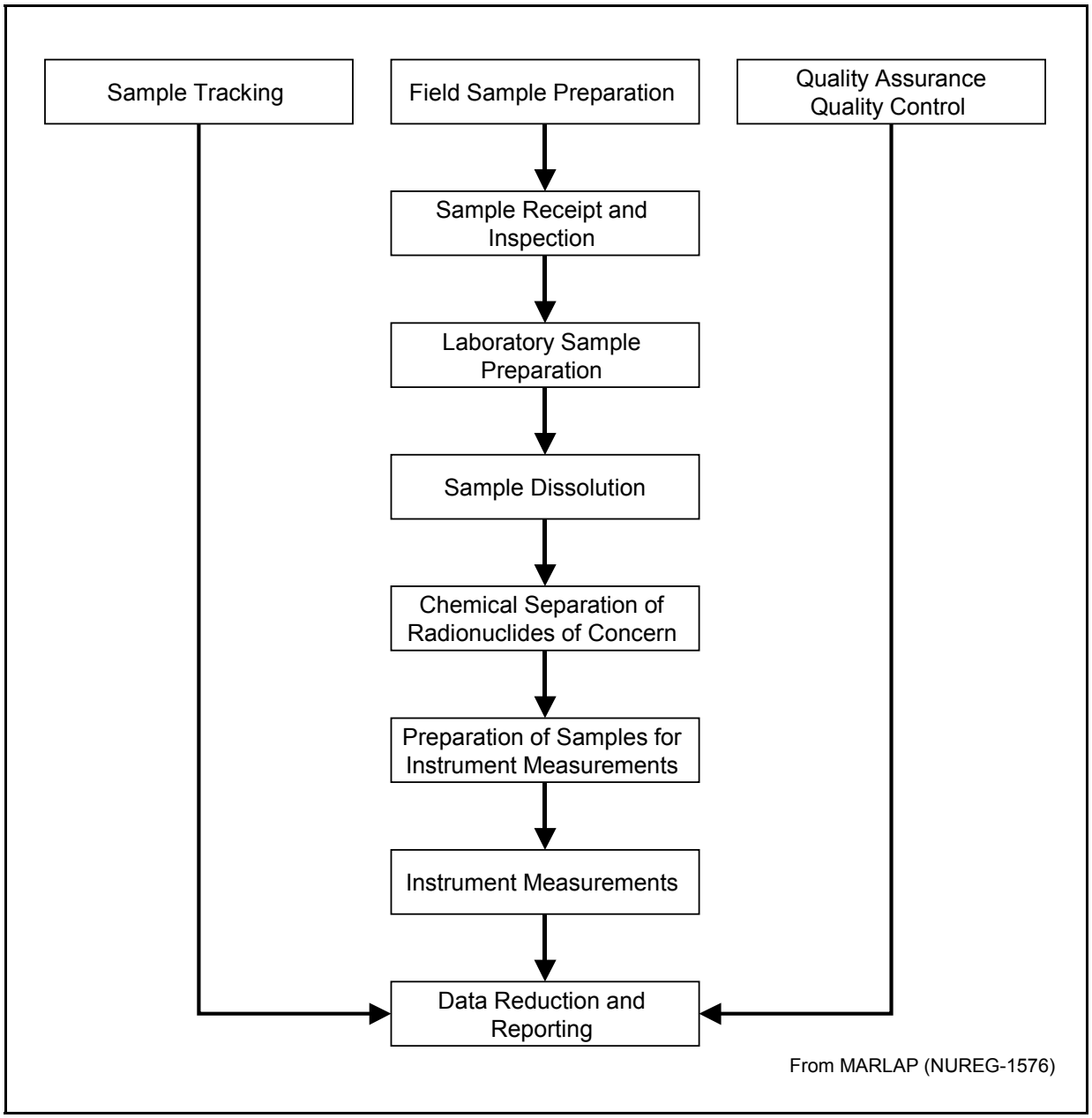

Figure D.2 Typical Components of the Radioanalytical Process

D.4 References

American Society for Testing and Materials (ASTM) D5792, "Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives," 1995.

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U.S. Environmental Protection Agency, U.S. Department of Defense, U.S. Department of Energy, U.S. Department of Homeland Security, U.S. Nuclear Regulatory Commission, U.S. Food and Drug Administration, U.S. Geological Survey, and National Institute of Standards and Technology, "Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP)," NUREG-1576, EPA402-B-04-001A, NTIS PB2004-105421, Vol. I, II, and III and Supp. 1. Washington, DC, 2004.

Changes to NUREG-1757, Vol. 2, Appendix E, "Measurements for Facility Radiation Surveys"

E.1 Introduction

This appendix is applicable to all decommissioning groups. All surveys, whether simple or complex final status surveys (FSSes), require information on the basis for instrument selection, the nature of the radionuclides, measurement techniques and procedures, MDCs of the instruments (measurement systems), and instrument calibration. Therefore, the information presented in this appendix would apply to a simple survey used to demonstrate compliance with regulatory decommissioning criteria as well as a complex FSS.

This appendix contains limited, general information on survey techniques and survey measurements. The information presented here is related to the process of implementing a survey plan and refers to the appropriate sections of MARSSIM, MARLAP, and various NUREGs for more detailed information. These are important areas for the conduct of surveys in the RSSI process and include the basic modes for determining levels of radiation and radioactivity at a site, instrument and scanning detection limits, instrument calibration, and laboratory measurements for samples. The data from the FSS is the deciding factor in judging if the site meets the release criteria.

Radiological conditions that should be determined for license termination purposes include any combination of total surface activities, removable surface activities, exposure rates, radionuclide concentrations in soil, or induced activity levels. To determine these conditions, field measurements and laboratory analyses may be necessary. For certain radionuclides or radionuclide mixtures, both alpha and beta radiations may have to be measured. In addition to assessing the average radiological conditions, small areas with elevated levels of residual radioactivity should be identified and their extents and activities determined. There are three basic modes in which one can operate in determining the levels of radiation and radioactivity at a site. They are scanning with hand-held survey instruments, direct measurements with these same or larger instruments, and sample collection at the site followed by analysis in the laboratory. In many cases, some combination of these modes would be used to obtain data, although the exact mix would be expected to vary according to the application.

In practice, the DQO process is used to obtain a proper balance among the uses of various measurement techniques. In general, there is an inverse correlation between the cost of a specific measurement technique and the detection levels being sought. Depending on the survey objectives, important considerations include survey costs and choosing the optimum instrumentation and measurement mix.

The decision to use a measurement method as part of the survey design is determined by the survey objectives and the survey unit classification. Scanning is performed to identify areas of elevated activity that may not be detected by other measurement methods. Direct measurements are analogous to collecting and analyzing samples to determine the average activity in a survey unit. Refer to Appendix O of this volume for information on lessons learned from recently

submitted DPs and questions and answers to clarify existing license termination guidance related to measurements for facility radiation surveys.

E.2 Direct Measurements (Fixed Measurements)

To conduct direct measurements of alpha, beta, and photon surface activity, instruments and techniques providing the required detection sensitivity are selected. The type of instrument and method of performing the direct measurement are selected as dictated by the type of residual radioactivity present, the measurement sensitivity requirements, and the objectives of the radiological survey.

Direct measurements may be collected at random locations in the survey unit. Alternatively, direct measurements may be collected at systematic locations and supplement scanning surveys for the identification of small areas of elevated activity. Direct measurements may also be collected at locations identified by scanning surveys as part of an investigation to determine the source of the elevated instrument response. Professional judgment may also be used to identify locations for direct measurements to further define the areal extent of residual radioactivity and to determine maximum radiation levels within an area, although these types of direct measurements are usually associated with preliminary surveys (i.e., scoping, characterization, remedial action support). All direct measurement locations and results shall be documented.

If the equipment and methodology used for scanning is capable of providing data of the same quality required for direct measurement (e.g., detection limit, location of measurements, ability to record and document results), then scanning may be used in place of direct measurements. Results should be documented for at least the number of locations required for the statistical tests. In addition, some direct measurement systems may be able to provide scanning data, provided they meet the objectives of the scanning survey.

Refer to Chapter 6 of MARSSIM for information on radiation measurements. Specifically, Section 6.4.1 of MARSSIM contains information on direct measurements for alpha, beta, and gamma emitting radionuclides.

E.3 Scanning Measurements

Scanning is the process by which the operator uses portable radiation detection instruments to detect the presence of radionuclides on a specific surface (i.e., ground, wall, floor, equipment). The term scanning survey is used to describe the process of moving portable radiation detectors across a suspect surface with the intent of locating residual radioactivity. Investigation levels for scanning surveys are determined during survey planning to identify areas of elevated activity. Scanning surveys are performed to locate radiation anomalies indicating residual gross activity that may require further investigation or action.

Areas of elevated activity typically represent a small portion of the site or survey unit. Thus, random or systematic direct measurements or sampling on the commonly used grid spacing may have a low probability of identifying these areas. Scanning surveys are often relatively quick and inexpensive to perform. For these reasons, scanning surveys are typically performed before direct measurements or sampling. In this way, time is not spent fully evaluating an area that may quickly prove to contain residual radioactivity above the investigation level during the scanning process. Based on the historical site assessment (HSA), surfaces to be surveyed, and survey design objectives, scans are conducted which would be indicative of all radionuclides potentially present. Surrogate measurements may be utilized where appropriate. Documenting scanning results and observations from the field is very important. For example, a scan that identified relatively sharp increases in instrument response or identified the boundary of an area of increased instrument response should be documented. This information is useful when interpreting survey results.

Refer to Chapter 6 of MARSSIM for information on radiation measurements. Specifically, Section 6.4.2 of MARSSIM contains information on scanning measurements for alpha, beta, and gamma emitting radionuclides.

E.4 Sampling

For certain radionuclides that cannot be effectively measured directly in the field, samples of the medium under investigation (e.g., soil) should be collected and then analyzed with a laboratory-based procedure. On the simplest level, this would include the analysis of a smear sample using a gross alpha-beta counter. More involved analyses would include gamma spectrometry, beta analysis using liquid scintillation counting, or alpha spectrometry following separation chemistry.

Samples from a variety of locations may be required, depending upon the specific facility conditions and the results of scans and direct measurements. Inaccessible surfaces cannot be adequately evaluated by direct measurements on external surfaces alone; therefore, those locations which could contain residual radioactive material should be accessed for surveying. Residue can be collected from drains using a piece of wire or plumber's "snake" with a strip of cloth attached to the end; deposits on the pipe interior can be loosened by scraping with a hard-tipped tool that can be inserted into the drain opening. Particular attention should be given to "low-points" or "traps" where activity would likely accumulate. The need for further internal monitoring and sampling is determined on the basis of residue samples and direct measurements at the inlet, outlet, cleanouts, and other access points to the pipe interior.

Residual activity will often accumulate in cracks and joints in the floor. These are sampled by scraping the crack or joint with a pointed tool such as a screwdriver or chisel. Samples of the residue can then be analyzed; positive results of such an analysis may indicate possible subfloor residual radioactivity. Checking for activity below the floor will require accessing a crawl space (if one is present) or removal of a section of the flooring. Coring, using a commercially available

unit, is a common approach to accessing the subfloor soil. After removing the core (whose diameter may range from a few centimeters to up to 20 centimeters), direct monitoring of the underlying surface can be performed and samples of soil collected.

Coring is also useful for collecting samples of construction material which may contain activity that has penetrated below the surface, or activity induced by neutron activation. This type of sampling is also applicable to roofing material which may contain embedded or entrapped contaminants. The profile of the distribution and the total radionuclide content can be determined by analyzing horizontal sections of the core.

If residual activity has been coated by paint or some other treatment, the underlying surface and the coating itself may contain residual radioactivity. If the activity is a pure alpha or low-energy beta emitter, measurements at the surface will probably not be representative of the actual residual activity level. In this case, the surface layer is removed from a known area, usually 100 cm^2, using a commercial stripping agent or by physically abrading the surface. The removed coating material is analyzed for activity content and the level converted to units of dpm/100 cm^2 for comparison with guidelines for surface activity. Direct measurements are performed on the underlying surface, after removal of the coating.

MARSSIM and ~~NUREG–1506~~ MARLAP contain information on sampling and laboratory analysis for decommissioning. ~~Additionally, laboratory procedures manuals contain information on specific analytical methods; an example can be found in the DOE Environmental Measurements Laboratory's EML Procedures Manual (HASL–300).~~ Refer to Section 10 of MARLAP for field and sampling issues that affect laboratory measurements.

E.5 Minimum Detectable Concentrations

Detection limits for field survey instrumentation are an important criteria in the selection of appropriate instrumentation and measurement procedures. For the most part, detection limits need to be determined in order to evaluate whether a particular instrument and measurement procedure is capable of detecting residual activity at the regulatory release criteria (DCGLs). One may demonstrate compliance with decommissioning criteria by performing surface activity measurements and directly comparing the results to the surface activity DCGLs. However, before any measurements are performed, the survey instrument and measurement procedures to be used must be shown to possess sufficient detection capabilities relative to the surface activity DCGLs.

The measurement of residual radioactivity during surveys in support of decommissioning often involves measurement of residual radioactivity at near-background levels. Thus, the minimum amount of radioactivity that may be detected by a given survey instrument and measurement procedure must be determined. In general, the minimum detectable concentration (MDC) is the minimum activity concentration on a surface or within a material volume, that an instrument is expected to detect (i.e., activity expected to be detected with 95 percent confidence). It is

important to note that this activity concentration, the MDC, is determined *a priori* (i.e., before survey measurements are conducted).

As generally defined, the detection limit, which may be a count or count rate, is independent of field conditions such as scabbled, wet, or dusty surfaces. That is, the detection limit is based on the number of counts and does not necessarily equate to measured activity under field conditions. These field conditions do, however, affect the instrument's "detection sensitivity" or MDC. Therefore, the terms MDC and detection limit should not be used interchangeably.

In MARSSIM, MARLAP, and other NRC NUREGs, the MDC corresponds to the smallest activity concentration measurement that is practically achievable with a given instrument and type of measurement procedure. That is, the MDC depends not only on the particular instrument characteristics (instrument efficiency, background, integration time, etc.) but also on the factors involved in the survey measurement process (EPA 1980), which include surface type, source-to-detector geometry, and source efficiency (e.g., backscatter and self-absorption).

~~A good discussion of the general and theoretical concepts of MDC can be found in Chapter 3 of NUREG–1507. Chapter 3 of NUREG–1507 also contains a useful comparison of MDC results using various MDC expressions.~~ See MARLAP Section 3.3.7, "Method Performance Characteristics and Measurement Quality Objectives" and Section 20, "Detection and Quantification Capabilities" for a discussion of MDCs.

E.6 Survey MDCs

During radiological surveys in support of decommissioning, scanning is performed to identify the presence of any locations of elevated direct radiation. The probability of detecting residual radioactivity in the field is affected not only by the sensitivity of the survey instrumentation when used in the scanning mode of operation, but also by the surveyor's ability. The surveyor must decide whether the signals represent only the background activity, or whether they represent residual radioactivity in excess of background.

The minimum detectable concentration of a scan survey, referred to as scan MDC or MDC_{scan}, depends on the intrinsic characteristics of the detector (efficiency, window area, etc.), the nature (e.g., type and energy of emissions) and relative distribution of the residual radioactivity (e.g., point versus distributed source and depth of residual radioactivity), scan rate, and other characteristics of the surveyor. Some factors that may affect the surveyor's performance include the costs associated with various outcomes—e.g., cost of missed residual radioactivity versus cost of incorrectly identifying areas as containing residual radioactivity—and the surveyor's *a priori* expectation of the likelihood of residual radioactivity present. For example, if the surveyor believes that the potential for residual radioactivity is very low, as in an unaffected area, then a relatively large signal may be required for the surveyor to conclude that residual radioactivity is present. NUREG/CR–6364, "Human Performance in Radiological Survey

Scanning," provides a complete discussion of the human factors as they relate to the performance of scan surveys.

Signal detection theory provides a framework for the task of deciding whether the audible output of the survey meter during scanning was due to background or signal plus background levels. An index of sensitivity (d') that represents the distance between the means of the background and background plus signal, in units of their common standard deviation, can be calculated for various decision errors—Type I error (α) and Type II error (β). As an example, for a correct detection or true positive rate of 95 percent ($1-\beta$) and a false positive rate (α) of 5 percent, d' is 3.29 (similar to the static MDC for the same decision error rates). The index of sensitivity is independent of human factors, and therefore, the ability of an ideal observer (i.e., theoretical construct) may be used to determine the minimum d' that can be achieved for particular decision errors. The ideal observer makes optimal use of the available information to maximize the percent correct responses and thus provides an effective upper bound against which to compare actual surveyors. Computer simulations and field experimentation can then be performed to evaluate the surveyor efficiency (p) relative to the ideal observer. The resulting expression for the ideal observer's minimum detectable count rate (*MDCR*), in cpm, can be written:

$$MDCR = d' \times \sqrt{b_i} \times (60/i) = s_i \times (60/i) \qquad \textbf{(E–1)}$$

where:

$MDCR$	=	minimum detectable (net) count rate in cpm,
b_i	=	background counts in the observation interval,
s_i	=	minimum detectable number of net source counts in the observation interval, and
i	=	observational interval (in seconds), based on the scan speed and areal extent of the residual radioactivity.

*Scan MDC*s are determined from the *MDCR* by applying conversion factors to obtain results in terms of measurable surface activities and soil concentrations. As an example, the *scan MDC* for a structure surface can be expressed as:

$$Scan\ MDC = \frac{MDCR}{\sqrt{p}\ \epsilon_i\ \epsilon_s\ \frac{probe\ area}{100\ cm^2}} \qquad \textbf{(E–2)}$$

Chapter 6 of NUREG–1507 contains an excellent discussion of survey MDCs. Included in this discussion are *scan MDC* equations for both building/structure surface scans and land area scans.

E.7 Survey Instrument Calibration

Before the MDC for a particular instrument and survey procedure can be determined, it is necessary to introduce the expression for total alpha or beta surface activity per unit area. In the International Organization for Standardization's (ISO) Guide 7503–1, "Evaluation of Surface Contamination," the ISO recommends that the total surface activity, A_S, be calculated similarly to the following expression:

$$A_s = \frac{R_{S+B} - R_B}{(\epsilon_i)(W)(\epsilon_s)} \qquad \textbf{(E–3)}$$

where R_{S+B} = the gross count rate of the measurement in cpm,
R_B = the background count rate in cpm,
ϵ_I = the instrument or detector efficiency (unitless),
ϵ_s = the efficiency of the residual radioactivity source (unitless), and
W = the area of the detector window (cm^2).

(For instances in which W does not equal 100 cm^2, probe area corrections are necessary to convert the detector response to units of dpm per 100 cm^2.)

This expression clearly distinguishes between instrument (detector) efficiency and source efficiency. The product of the instrument and source efficiency yields the total efficiency, ϵ_{tot} . Currently, surface residual radioactivity is assessed by converting the instrument response to surface activity using one overall total efficiency. This is not a problem provided that the calibration source exhibits characteristics similar to the surface residual radioactivity—including radiation energy, backscatter effects, source geometry, self-absorption, etc. In practice this is hardly the case; more likely, total efficiencies are determined with a clean, stainless steel source, and then those efficiencies are used to measure residual radioactivity on a dust-covered concrete surface. By separating the efficiency into two components, the surveyor has a greater ability to consider the actual characteristics of the surface residual radioactivity.

The instrument efficiency is defined as the ratio between the net count rate of the instrument and the surface emission rate of a source for a specified geometry. The surface emission rate, $q_{2\pi}$, is defined as the "number of particles of a given type above a given energy emerging from the front face of the source per unit time" (ISO 7503–1). The surface emission rate is the 2π particle fluence that embodies both the absorption and scattering processes that affect the radiation emitted from the source. Thus, the instrument efficiency is determined by

$$\epsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}} \qquad \textbf{(E–4)}$$

The instrument efficiency is determined during calibration by obtaining a static count with the detector over a calibration source that has a traceable activity or surface emission rate or both. In many cases, it is the source surface emission rate that is measured by the manufacturer and certified as National Institute of Standards and Technology (NIST) traceable. The source activity is then calculated from the surface emission rate based on assumed backscatter and self-absorption properties of the source. The theoretical maximum value of instrument efficiency is one.

The source efficiency, ϵ_s, is defined as the ratio between the number of particles of a given type emerging from the front face of a source and the number of particles of the same type created or released within the source per unit time (ISO 7503–1). The source (or surface) efficiency takes into account the increased particle emission due to backscatter effects, as well as the decreased particle emission due to self-absorption losses. For an ideal source (no backscatter or self-absorption), the value of ϵ_s is 0.5. Many real sources will exhibit values of ϵ_s less than 0.5, although values greater than 0.5 are possible, depending on the relative importance of the absorption and backscatter processes. Source efficiencies may either be determined experimentally or simply selected from the guidance contained in ISO 7503–1.

Some of the factors that affect the instrument efficiency, ϵ_I, include detector size (probe surface area), window density thickness, geotropism, instrument response time, and ambient conditions such as temperature, pressure, and humidity. The instrument efficiency also depends on the radionuclide source used for calibration and the solid angle effects, which include source-to-detector distance and source geometry.

Some of the factors that affect the source efficiency, ϵ_s, include the type of radiation and its energy, source uniformity, surface roughness and coverings, and surface composition (e.g., wood, metal, concrete).

Surface activity levels are assessed by converting detector response, through the use of a calibration factor, to radioactivity. Once the detector has been calibrated and an instrument efficiency (ϵ_I) established, several factors must still be carefully considered when using that instrument in the field. These factors involve the background count rate for the particular surface and the surface efficiency (ϵ_s), which addresses the physical composition of the surface and any surface coatings. Ideally, the surveyor should use experimentally determined surface efficiencies for the anticipated field conditions. The surveyor needs to know how and to what degree these different field conditions can affect the sensitivity of the instrument. A particular field condition may significantly affect the usefulness of a particular instrument (e.g., wet surfaces for alpha measurements or scabbled surfaces for low-energy beta measurements).

One of the more significant implicit assumptions commonly made during instrument calibration and subsequent use of the instrument in the field is that the composition and geometry of residual radioactivity in the field is the same as that of the calibration source. This may not be the case, considering that many calibration sources are fabricated from materials different from those that comprise the surfaces of interest in the field [e.g., activity plated on a metallic disc

(Walker 1994)]. This difference usually manifests itself in the varying backscatter characteristics of the calibration and field surface materials.

Generally, it will not be necessary to recalculate the instrument MDC to adjust for the field conditions. The instrument detection limit (in net counts or net count rate) remains the same, but the surface activity MDC may be different (due to the varying ϵ_s).

Refer to Chapter 4 of NUREG–1507 for a discussion of survey instrument calibration and the effects of efficiency changes on MDC. Chapter 5 of NUREG–1507 discusses variables affecting efficiencies in the field. Section 20 of MARLAP discusses instrument efficiency and the minimum detectable net instrument signal.

E.8 Laboratory Measurements

Frequently during surveys in support of decommissioning it is not feasible, or even possible, to detect the residual radioactivity with portable field instrumentation; thus arises the need for laboratory analysis of media samples. This is especially the case for such media samples as soil, that result in significant self-absorption of the radiation from the residual radioactivity. Another common situation that necessitates the use of laboratory analyses occurs when the residual radioactivity is difficult to detect even under ideal conditions. This includes residual radioactivity that emits only low-energy beta radiation (e.g., H-3 and Ni-63) or X–ray radiation (e.g., Fe-55). Laboratory analyses for radionuclide identification, using spectrometric techniques, are often performed during scoping or characterization surveys. Here the principal objective is to simply determine the specific radionuclides present in the residual radioactivity, without necessarily having to assess the quantity of residual radioactivity. Once the residual radioactivity has been identified, sufficiently sensitive field survey instrumentation and techniques are selected to demonstrate compliance with the DCGLs.

Samples collected during surveys for decommissioning purposes should be analyzed by trained individuals using the appropriate equipment and procedures at a well-established laboratory, which uses either inhouse or contractor laboratory services. There should be written procedures that document both (a) the laboratory's analytical capabilities for the radionuclides of interest and (b) the QA/QC program which assures the validity of the analytical results. Many of the general types of radiation detection measuring equipment used for survey field applications are also used for laboratory analyses, usually under more controlled conditions which provide for lower detection limits and greater delineation between radionuclides. Laboratory methods often also involve a combination of both chemical and instrumental technique to quantify the low levels expected to be present in samples from decommissioning facilities.

To reemphasize, a thorough knowledge of the radionuclides present, along with their chemical and physical forms and their relative abundance, is a prerequisite to selecting laboratory methods. With this information, it may be possible to substitute certain gross (i.e., nonradionuclide specific) measurement techniques for the more costly and time-consuming wet chemistry

separation procedures and relate the gross data back to the relative quantities of specific contaminants. The individual responsible for the survey should be aware that radiochemical analyses require lead times which will vary, according to the nature and complexity of the request. For example, a lab may provide fairly quick turnaround on gamma spectrometry analysis because computer-based systems are available for interpretation of gamma spectra. On the other hand, soil samples, which must be dried and homogenized, will require much longer lead time. Some factors influencing the analysis time include (a) the nuclides of concern, (b) the type of samples to be analyzed, (c) the QA/QC considerations required, (d) the availability of adequate equipment and personnel, and (e) the required detection limits.

For relatively simple analyses, such as gross alpha and gross beta counting of smears and water samples, liquid scintillation spectrometry for low-energy beta emitters in smear and water samples, and gamma-spectrometry of soil, it is usually practical to establish in-house laboratory capabilities. The more complicated and labor-intensive procedures, such as alpha spectrometry, Sr-90 and low-energy beta emitters (H-3, Ni-63, etc.) in soil samples, should be considered candidates for contract laboratory analyses.

Analytical methods should be capable of measuring levels below the established release guidelines, detection sensitivities of 10 to 25 percent of the guideline should be the target. Although laboratories will state detection limits, these limits are usually based on ideal situations and may not be achievable under actual measurement conditions. Also, remember that detection limits are subject to variation from sample to sample, instrument to instrument, and procedure to procedure depending upon sample size, geometry, background, instrument efficiency, chemical recovery, abundance of the radiations being measured, counting time, self-absorption in the prepared sample, and interference from other radionuclides present.

MARSSIM and ~~NUREG–1506~~ MARLAP contain information on sampling and laboratory analysis for decommissioning. ~~Additionally, laboratory procedures manuals, such as the Department of Energy's Environmental Measurements Laboratory's EML Procedures Manual (HASL–300), contain information on specific analytical methods.~~ MARLAP Sections 12, 13, 14, and 15 discuss laboratory sample preparation, sample dissolution, separation techniques, and quantification of radionuclides.

E.9 References

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Changes to NUREG-1757, Vol. 2, Appendix I, Section I.2, "Source-Term Abstraction"

I.2 Source-Term Abstraction

~~This information was taken from NUREG–1727, Appendix C, Section 3. The section has been revised, appropriately, to remove redundancy, and use consistent terminology in this document, but the essential information is the same.~~

I.2.1 Introduction

Source-term abstraction is the process of developing a conceptual representation of the radioactive source at a site. Typically, the radiological conditions at a site proposed for decommissioning are relatively complex. Source-term abstraction is necessary to allow the detailed radiological characterization of the site to be incorporated into the mathematical and computer models that are used to estimate radiological impacts (e.g., dose). The abstraction process involves generalizing the radiological characteristics across the site to produce a simplified representation, which should facilitate the modeling of radiological impacts. The conceptual representation of the source developed in the abstraction process, however, should not be simplified to the extent that radiological impacts are significantly underestimated or unrealistically overestimated.

As discussed in Chapter 5 of this volume, source-term abstraction serves as the starting point for the dose modeling process. The conceptual abstraction of the source term is combined with the physical characteristics of the site and characteristics of the critical group receptor to develop the conceptual model for the site. This conceptual model provides the basis for identifying applicable exposure scenarios, pathways, and selection of computer models. These other elements of dose modeling are discussed in subsequent sections of this document.

Volume 1 of NUREG–1757 and Chapter 4 of this volume discuss the information the licensee is expected to provide regarding the existing radiological characterization of the site. The licensee should provide a description of the types, levels, and extent of radioactive material contaminated at the site. This should include residual radioactivity in all media (including buildings, systems and equipment that will remain after license termination, surface and subsurface soil, and surface and subsurface ground water). The source-term abstraction should be based on the characterization of the radiological status (e.g., process historical development, records of leakage or disposal). The licensee should explicitly relate the information provided in the discussion of radiological status of the site with the discussion of source-term abstraction. The reviewer should be able to clearly interpret the relationship.

Generally, in the source-term abstraction process, the licensee may focus on several specific elements of the source term, which include the following:

1. The licensee should identify the radionuclides of concern. This should be taken directly from the description of the site's radiological status. The radionuclides should be identified based on pre-remediation radiological status. All radionuclides potentially

present at the site should be included, so that their presence or absence may be verified during the FSS, except as noted in Chapter 4 and Section 3.3 of this volume.

2. The licensee should describe the physical/chemical form(s) of the contaminated media *anticipated at the time of FSS and site release*. The licensee should indicate whether the residual radioactivity will be limited to building surfaces and/or surface soil, or whether the residual radioactivity will involve other media such as subsurface soil, debris or waste materials (e.g., sludge, slag, tailings), or ground and surface water.

3. The licensee should delineate the spatial extent of the residual radioactivity *anticipated at the time of FSS and site release*. The delineation of the spatial extent should include descriptions of (a) the areal extent of radionuclides throughout the site and (b) the vertical extent of soil residual radioactivity of radionuclides below the ground surface. The delineation of spatial extent and depth should establish the source areas and volumes. Depending on the presence of specific radionuclides, source areas and volumes may be radionuclide-specific.

4. The licensee should define the distribution of each radionuclide throughout the delineated source areas and volumes *anticipated at the time of FSS and site release*. The distribution of a radionuclide through the source should be defined in terms of representative volumetric or areal concentrations. In addition, for volumetrically contaminated soil, the licensee may provide an estimate of total radioactivity of each radionuclide.

5. The licensee should define sources in ground water or surface water, if any, based on environmental monitoring and sampling of aquifers and surface water bodies. A site with ground water or surface water contamination may be categorized as "complex" and may require more advanced dose modeling analysis (see Section 1.3 of this volume).

In the source-term abstraction process, the licensee should address the first two of these five elements. Whether the licensee needs to address the other elements depends on the objective of the licensee's dose modeling. This is discussed later in this section.

I.2.2 Issues Associated with Source-Term Abstraction

The level of effort that a licensee expends to develop a conceptualization of a source term should be commensurate with the licensee's approach to demonstrating compliance with the release criterion. Also, the focus should be on the source-term characteristics anticipated to exist at the site at the time of FSS and release, after any planned remediation.

If a licensee plans to use the screening DCGLs published by NRC in the *Federal Register*, a licensee should only have to identify the radionuclides that may be present at the site, and demonstrate that the conditions at the site meet the prerequisites for using the screening values [i.e., residual radioactivity is limited to building surfaces or the uppermost 15 to 30 cm (6 to 12 in) of surface soil and no contamination of ground water or surface water]. The licensee's

source-term abstraction would not have to address issues such as existing radiological conditions, areal and volumetric extent of residual radioactivity, or spatial variability or radiological conditions for such sources. This is discussed further in Section I.2.3 of this appendix.

If a licensee anticipates that residual radioactivity will be limited to building surfaces or surface soils at the time of FSS, but considers the published DCGLs overly restrictive, the licensee may develop site-specific DCGLs. In this case, the licensee would most likely have to delineate the anticipated areal extent of residual radioactivity. However, the licensee would not have to discuss the anticipated spatial variability of radionuclide concentrations within the anticipated area of residual radioactivity.

A licensee should provide a site-specific dose assessment if the residual radioactivity is not limited to building surfaces or surface soil. In this case, the licensee would have to delineate the spatial extent (laterally and vertically) of the residual radioactivity, and the licensee would have to provide a discussion of the spatial variability of the physical, chemical, and radiological characteristics of the contaminated media.

Ideally, the source characteristics at a site would be relatively uniform, justifying simplified abstraction. However, this is generally not the case. Issues may arise when the residual radioactivity projected at a site at the time of release falls short of the ideal case. These issues may include the following:

1. Spatial extent
   - limited areal extent of residual radioactivity;
   - irregular areal shape; and
   - varying depth of residual radioactivity in soil.
2. Spatial variability
   - nonuniform distribution of radioactivity throughout a site;
   - limited areas of relatively elevated radionuclide concentrations;
   - multiple noncontiguous areas of residual radioactivity; and
   - nonuniform physical and chemical characteristics.

The following approach to source-term abstraction addresses most of these issues. Others (e.g., irregular areal shape) are best addressed by appropriate selection of computer codes.

I.2.3 Approach to Source-Term Abstraction

A licensee's approach to source-term abstraction will depend on the objective of the dose modeling presented in the decommissioning plan (DP). Generally, the licensee's dose modeling should have one of the following objectives:

- Develop DCGLs commensurate with demonstrating compliance with the dose-based release criterion, and then demonstrate through FSS that residual radioactivity concentrations at the site are equal to or below the DCGLs.
- Assess dose associated with actual concentrations of residual radioactivity distributed across the site to determine whether the concentrations will result in a dose that is not equal to or below the regulatory dose criterion.

In the first objective, the licensee intends to demonstrate at the time of FSS before release that residual radionuclide concentrations across the site are below a prespecified concentration limit with some prespecified degree of confidence. The design of the FSS would be based on the proposed DCGLs, in accordance with MARSSIM. The MARSSIM process does not require that the licensee incorporate information regarding the existing (i.e., pre-remediation or pre–FSS) spatial distribution of radioactivity into the source-term abstraction. The identification of DCGLs may involve site-specific model and parameter assumptions, or may use "screening" analyses.

In the second objective, the licensee intends to assess potential radiation doses that may result from specified levels of radioactive material. The contaminated material may not be limited to building surfaces or surface soils, but may include contaminated subsurface soil, debris, and waste. The licensee's dose modeling should demonstrate that the residual radioactivity should not result in radiation doses in excess of applicable regulatory limits. This modeling would likely be site-specific. Most likely, this modeling objective would require that the licensee incorporate information regarding both the spatial extent and spatial variability of radioactivity into the source-term abstraction.

Table I.1 summarizes the approach to source-term abstraction that the licensee should adopt, depending on the licensee's dose modeling objective and whether the licensee is providing screening or site-specific analyses. This table can serve as an index for the reviewer of the licensee's source-term abstraction.

Table I.1 Summary of Source-Term Abstraction Approaches Based on Dose-Modeling Objective

Objective	Screening	Site-Specific
Identify DCGLs.	No source-term abstraction is necessary beyond radionuclide identification. (Assume unit radionuclide concentrations.)	Delineate proposed lateral and vertical extent of residual contamination. (Assume unit radionuclide concentrations.)
Provide Dose Assessment.	Use actual concentrations with DandD v2.1 and assure that spatial variability is minimal.	Site-specific source-term abstraction incorporating spatial extent and variability.

I.2.3.1 Dose Modeling Objective One: Identify DCGLs

The MARSSIM approach, as documented in NUREG–1575 (NRC 1997) and discussed in Chapter 4 of this volume, requires that a licensee establish a set of DCGLs before conducting an FSS. In fact, the design of the FSS should be based on the identified DCGLs. DCGL is defined in MARSSIM as:

> "*...a derived, radionuclide-specific activity concentration within a survey unit corresponding to the release criterion.... DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.*"

The $DCGL_W$ is the concentration of a radionuclide which, if distributed uniformly across a survey unit, would result in an estimated dose equal to the applicable dose limit. The $DCGL_{EMC}$ is the concentration of a radionuclide which, if distributed uniformly across a smaller limited area within a survey unit, would result in an estimated dose equal to the applicable dose limit.

Two approaches are possible for developing DCGLs: screening and site-specific analysis.

SCREENING DCGLs

NRC has published radionuclide-specific screening DCGLs in the *Federal Register* for residual building-surface radioactivity and residual surface-soil radioactivity. The DCGLs in the *Federal Register* are intended to be concentrations which, if distributed uniformly across a building or soil surface, would individually result in a dose equal to the dose criterion. The licensee may adopt these screening DCGLs without additional dose modeling, if the site is suitable for screening analysis. Alternatively, the licensee may use the DandD computer code to develop screening DCGLs. The licensee would use the code to determine the dose attributable to a unit

concentration of a radionuclide and scale the result to determine the $DCGL_W$ for the radionuclide. Either of these methods for identifying screening DCGLs requires the licensee (a) to identify the radionuclides of concern for the site and (b) to demonstrate that the source term and model screening assumptions are satisfied. Thus, this approach requires essentially no source-term abstraction. The screening process and the source-term screening assumptions are discussed in detail in Appendix H of this volume.

Before designing an FSS, the licensee may likely need to identify a $DCGL_{EMC}$ for each radionuclide over a range of smaller limited areas. Since the conservative screening models of DandD are not appropriate for modeling small limited areas of residual radioactivity, use of the DandD screening code would likely result in $DCGL_{EMC}$ values that are overly conservative. Therefore, licensees may likely use other codes or approaches to develop $DCGL_{EMC}$ values. These would be considered "site-specific" analyses in that they would not be using the DandD code with the default screening values. See Section I.3.3.3.5 of this appendix for more information.

SITE-SPECIFIC DCGLs

The licensee may choose to identify site-specific DCGLs if (a) the site conditions are not consistent with screening criteria or (b) the licensee believes the screening DCGLs are unnecessarily restrictive. As defined in MARSSIM, the site-specific DCGLs may be derived from activity/dose relationships through various exposure pathway scenarios. "Site-specific" in this context may refer to the selection of conceptual models/computer models, physical (site) input parameter values, or behavioral/metabolic input parameter values. These aspects of site-specific analyses are discussed in other sections of this document. "Site-specific" may also refer to the source-term abstraction.

From the MARSSIM perspective, identifying a site-specific $DCGL_W$ still begins with assuming a uniform radionuclide concentration across some source area (building surface) or volume (surface soil). The site-specific $DCGL_W$ for a particular radionuclide may be identified by evaluating the dose resulting from a unit concentration and then scaling the result. Spatial variability of the radionuclide concentration within the area or volume is not evaluated in identifying the DCGLs, but is taken into account in the statistical analysis of the data collected during the FSS. In identifying the site-specific DCGLs, the licensee may, however, take the spatial extent into account.

If the licensee is certain that the residual radionuclide concentration is limited to a specific lateral extent, the licensee may incorporate the "area of residual radioactivity" into the identification of DCGLs. Computer modeling codes, such as RESRAD or DandD, allow the user to directly specify the area of residual radioactivity. Through the FSS, the licensee would have to demonstrate that the $DCGL_W$ is satisfied within the specified area of residual radioactivity, and would have to demonstrate that residual radioactivity is not present outside the specified area of

residual radioactivity. In order to adequately design the FSS, the licensee should develop $DCGL_{EMC}$ values for smaller areas within the area of residual radioactivity.

In addition to specifying a limited area of residual radioactivity in developing the site-specific DCGLs for soil, the licensee should also appropriately represent the vertical extent of residual radioactivity within the area. The screening DCGLs and the DandD code assume that residual radioactivity is contained within the uppermost 15 to 30 cm (6 to 12 in) of soil. If the licensee intends to leave residual radioactivity at depths below 15 to 30 cm (6 to 12 in), this should be reflected in the calculation of the $DCGL_W$. Otherwise, leaving residual radioactivity below 15 to 30 cm (6 to 12 in) may not be acceptable.

For subsurface residual radioactivity [i.e., residual radioactivity at depths greater than 15 to 30 cm (6 to 12 in)], the NRC license reviewer should evaluate whether the licensee has reviewed existing historical site data (including previous processes or practices) and site characterization data to establish an adequate conceptual model of the subsurface source specifically regarding horizontal and vertical extent of residual radioactivity. Lateral and vertical trends of variation in concentration for each specific radionuclide should be evaluated. Since certain radionuclides have higher mobility than others, radionuclide ratios may not be maintained as constant across subsurface soil. In other words, radionuclide concentration within the unsaturated zone may vary depending on the original source location and the time since contamination existed. The NRC license reviewer should evaluate whether the licensee has reviewed the physical and chemical properties of the source and the surface/subsurface formation to assess potential for leaching or retardation within the natural physical system of the concerned site. In this context, the NRC license reviewer should evaluate the selected physical parameters and the physical conceptual model of the site versus actual subsurface geologic units or formation to ensure conservative selection of pertinent sensitive physical parameters. The NRC license reviewer should also consider (a) the physical variability in subsurface soil and the unsaturated zone and (b) the selected depth to the water table considering the lower boundary of the subsurface source term.

If the thickness of residual radioactivity that the licensee intends to leave at the site is generally uniform across the site, the licensee may choose to use an upper bounding value for modeling the thickness. Alternatively, the licensee may choose to adopt an area-weighted approach to calculate an representative thickness. The representative thickness may be the area-weighted average value, or may reflect a conservative upper-percentile value. The NRC license reviewer should ensure that the representative thickness value proposed by the licensee does not significantly underestimate localized thicknesses at sites where the thickness of the proposed residually contaminated soil varies greatly across the site.

If appropriate, the licensee should provide maps and cross-sections detailing the proposed lateral and vertical extent of residual radioactivity left on the site.

I.2.3.2 Dose Modeling Objective Two: Assess Dose

An alternative objective that a licensee may have for performing and submitting dose modeling may be to assess doses attributable to specific quantities of radioactive material. Although the development of DCGLs focuses on the determination of radionuclide concentrations corresponding to a specified dose, the dose assessment objective focuses on the determination of doses corresponding to specified radionuclide concentrations.

In this situation, the licensee should give much more attention to the source-term abstraction. The licensee should address all elements of the source-term abstraction:

- identify the radionuclides of concern;
- delineate the spatial extent of residual radioactivity;
- represent the spatial variability of residual radioactivity; and
- incorporate spatial variability of physical and chemical characteristics of the contaminated media.

The licensee should focus on the distribution of radioactive material expected to be present at the time of FSS and subsequent site release. The licensee may assess doses attributable to existing radiological conditions at the site if the licensee can demonstrate that the existing radiological conditions reasonably bound conditions expected at FSS, from a dose perspective.

The first two elements of source-term abstraction—radionuclides of concern and spatial extent — were considered in the discussion of source-term abstraction for development of DCGLs. Spatial variability was not considered since it is statistically evaluated after FSS. In dose assessment, however, spatial variability should be factored into the source-term abstraction before dose modeling.

Assuming that the licensee has identified the radionuclides of concern and delineated the spatial extent of residual radioactivity, the licensee should provide a projection of residual radionuclide concentration distribution and total residual radionuclide inventory across the site. This projection should be directly tied to the characterization of existing radiological conditions at the site. The site may then be divided into relatively large areas that are radiologically distinct, based on radionuclide concentration or depth of residual radioactivity. The licensee should statistically demonstrate that the radionuclide concentrations or depth within an area may be relatively uniform, taking into account the spatial distribution of the data. Similarly, within the larger areas, the licensee should statistically delineate relatively small areas of projected elevated radionuclide concentrations or increased depth. (The licensee should discuss the reason for leaving the elevated concentrations in place as residual radioactivity.)

When complete, the licensee's source-term abstraction should define a site divided into relatively large areas of statistically uniform radionuclide concentrations and residual radioactivity depth. Within these areas may be relatively small areas of elevated concentration or increased depth. Assuming that the physical and chemical conditions across the site are relatively uniform, the licensee may use this source-term abstraction for modeling and proceed with the dose assessment. The following is a suggested approach:

- Consider each relatively large area independently, and initially ignore the relatively small elevated areas within each large area.
- Assess dose based on the properties of a large area, taking the areal extent into account.
- Repeat the dose assessment, but assume essentially infinite areal extent. The specific approach will depend on the computer modeling code used. This should quantify the impact of dividing the site into artificial modeling areas.
- Assess dose attributable to each limited area of elevated concentration, assuming no residual radioactivity exists outside the limited area. This may then be combined with the dose attributable to the surrounding larger area, to assess the impact of leaving the elevated concentrations.

In some cases, it may not be practical to separate a site into areas with relatively uniform radionuclide concentrations; sometimes areas to be evaluated will have non-uniform distributions of concentrations. In such cases, for performing the second step above, there may be a question about what statistical value best represents the radionuclide concentration for the large area. Log-normal distributions occur frequently in nature and are not unexpected when surveying contaminated sites. For log-normal distributions, the geometric mean is often used as a descriptor of the distribution. However, the geometric mean concentration should not be used as the average value for the source term for dose calculations. Arithmetic means reflect that (1) the dose rate is proportional to radionuclide concentration; (2) the dose receptor spends an equal amount of time in each area of the site; and (3) each characterization data point represents an equal area. Therefore, the arithmetic mean is the appropriate statistic to use for calculating source term average concentrations for the large areas (second step above) for dose modeling.

The above discussion does not specifically address the determination of relatively significant large or small areas. This designation will depend on the areal assumptions underlying the computer modeling code used. For example, the DandD code considers the area of cultivation to be uniformly contaminated and irrigated. The area of cultivation depends on the cultivation requirements defined by the specific exposure scenario. Conversely, the RESRAD code considers a range of exposure-pathway specific areas [e.g., 400 m^2 (4300 ft^2) for soil ingestion; 1000 m^2 (11,000 ft^2) for plant ingestion; and 20,000 m^2 (5 ac) for milk and meat ingestion]. Therefore, the licensee should discuss and justify the designation of relatively large and relatively small areas, based on the computer code used. However, by providing the additional assessments identified above, where alternative areas are evaluated, the sensitivity of the dose modeling results to the area designation can be determined.

The licensee may also have to consider the impact of multiple areas of elevated concentration within a single larger area. In general, modeling two small areas independently and combining the results of the two dose assessments should result in a higher dose than if the two areas were combined and modeled as a single area. The higher dose is unrealistic in that it assumes that the receptor location relative to each contaminated area is such that the dose is maximized from each contaminated area independently. For a more reasonable estimate of potential dose, these smaller areas may be combined into a single larger area if the concentrations within the smaller areas are comparable. If this is not the case, then the licensee may model each smaller area individually and modify the scenario and critical group assumptions for each area (e.g., time spent on each area) and combine the results.

Changes to NUREG-1757, Vol. 2, Section 2.1, "Risk-informed Approach to Compliance Demonstrations and Reviews"

2.1 RISK-INFORMED APPROACH TO COMPLIANCE DEMONSTRATIONS AND REVIEWS

This section provides a summary of the risk-informed approach to regulatory decisionmaking. Additional details can be found in the NRC Staff Requirements Memorandum, SECY–98–144 (NRC 1999).

NRC has increased the use of risk information and insights in its regulation of nuclear materials and nuclear waste management, including the decommissioning of nuclear facilities. Risk is defined by the "risk triplet" of (1) either a scenario or set of scenarios with a combination of events and/or conditions that could occur, (2) the probability that the scenario(s) could occur, and (3) the consequence (e.g., the dose to an individual) if the scenario(s) were to occur. The term risk insights, as used here, refers to the results and findings that come from risk assessments. The end results of such assessments may relate directly or indirectly to public health effects (e.g., the calculation of predicted doses from decommissioned sites).

A risk-based approach to regulatory decisionmaking is based solely on the numerical results of a risk assessment. The Commission does not endorse a risk-based regulatory approach but supports a risk-informed approach to regulation. A risk-informed approach to regulatory decisionmaking represents a philosophy whereby risk insights are considered together with other factors in the regulatory process to better focus licensee and regulatory attention on design and operational issues commensurate with their importance to public health and safety. Explicit consideration of the numerical probability that a scenario would occur (i.e., number 2 of the risk triplet) is not typically used by the NRC staff to determine compliance with the LTR. This is a departure from a purely risk-based approach.

The typical deterministic approach to regulatory decisionmaking establishes requirements for engineering margin and for quality assurance in design, manufacture, and construction. In addition, it assumes that adverse conditions can exist and establishes a specific set of design basis events (i.e., What can go wrong?). The deterministic approach involves implied, but unquantified, elements of probability in the selection of the specific design basis events to be analyzed. Then, it requires that the design include safety systems capable of preventing and/or mitigating the consequences (i.e., What are the consequences?) of those design basis events in order to protect public health and safety. Thus, a deterministic analysis explicitly addresses only two questions of the risk triplet.

The risk-informed approach has enhanced the deterministic approach by (a) allowing explicit consideration of a broader set of potential challenges to safety; (b) providing a logical means for prioritizing these challenges based on risk significance, operating experience, and/or engineering judgment; (c) facilitating consideration of a broader set of resources to defend against these challenges; (d) explicitly identifying and quantifying sources of uncertainty in the analysis (although such analyses do not necessarily reflect all important sources of uncertainty); and

(e) leading to better decisionmaking by providing a means to test the sensitivity of the results to key assumptions.

Where appropriate, a risk-informed regulatory approach can also be used to reduce unnecessary conservatism in purely deterministic approaches, or can be used to identify areas with insufficient conservatism in deterministic analyses and provide the bases for additional requirements or regulatory actions. Risk-informed approaches lie between the risk-based and purely deterministic approaches (NRC 1999).

NRC's risk-informed regulatory approach to the decommissioning of nuclear facilities is intended to focus the attention and resources of both the licensee and NRC on the more risk-significant aspects of the decommissioning process and on the elements of the facility and the site that will most affect risk to members of the public following decommissioning. While a licensee must comply with all Commission regulations, a licensee whose sites (or aspects of a site) have higher risk significance may need to provide a more rigorous demonstration to support compliance. Furthermore, NRC staff generally will apply more scrutiny to reviews of such sites or situations with higher risk significance. This should result in a more effective and efficient regulatory process. The risk-informed regulatory approach to decommissioning is reflected in this volume, as shown by the following examples:

- NRC has developed and is applying the concept of "decommissioning groups" based on (a) the nature and the extent of the radioactive material present at a site and (b) the complexity of the decommissioning process. The groups are generally related to the potential risks associated with the site, in that the less complex sites with limited distribution of radioactive material may pose lower risks (i.e., manageable risks) to individuals and populations during and following decommissioning (see Section 1.3).
- NRC's framework for decommissioning regulatory decisionmaking reflects the iterative nature of the compliance demonstration process. The iterative approach to decisionmaking for license termination provides a process for screening sites and for directing additional data collection effort toward demonstrating compliance. The framework is designed such that the level of complexity and rigor of analysis conducted for a given site should be commensurate with the level of risk posed by the site (see Section 1.5).
- This volume provides two different approaches for demonstrating compliance with the dose-based decommissioning criteria, using either a dose modeling approach or a DCGL approach. The dose modeling approach uses measurements of the actual residual radioactivity at a site after cleanup to more realistically assess the potential dose, and therefore the risk, associated with a decommissioned site. The DCGL approach allows a licensee to calculate, a priori, a concentration limit (DCGL) for each radionuclide based on the dose criteria of the LTR, and to then demonstrate that the residual radionuclide concentrations are below the DCGLs (see Section 2.5).

- This volume provides for demonstrating compliance through either a screening approach or a site-specific approach. The screening approach allows sites that pose lower potential risks to demonstrate compliance through simpler, yet conservative, screening analysis by adopting screening DCGLs developed by NRC (see Sections 2.6 and 5.1 and Appendix H).
- NRC staff recommends using the Data Quality Objectives (DQO) process for establishing criteria for data quality and developing survey designs. The process uses a graded approach to data quality requirements, based on the type of survey being designed and the risk of making a decision error based on the data collected. This process aligns the resources expended to collect and analyze data with the risk-significance of the data (see Section 3.2).
- NRC provides for an approach to dose assessment that accounts for the site-specific risk significance of radionuclides and exposure pathways. NRC staff allows a licensee to identify radionuclides and exposure pathways that may be considered "insignificant" based on their contribution to risk, and remove them from further consideration (see Section 3.3).
- NRC endorses the MARSSIM approach to FSS design and execution. The MARSSIM approach results in a site-specific FSS design that is commensurate with potential risks associated with a site, in terms of the likelihood of exceeding the DCGLs at the site (see Section 4.4).
- NRC staff supports a risk-informed approach to site-specific dose modeling for compliance demonstration in several ways: (a) allowing for site-specific selection of risk-significant exposure scenarios, exposure pathways, and critical groups; (b) expecting selection of conceptual models, numerical models and computer codes that incorporate the more risk-significant elements of a site; (c) expecting site-specific data for the more risk-significant input parameters, and allowing for more generic data for less risk-significant parameters; and (d) encouraging the use of probabilistic techniques to evaluate and quantify the magnitude and effect of uncertainties in the risk assessment, and the sensitivity of the calculated risks to individual parameters and modeling assumptions (see Appendix I).
- NRC allows for early partial release of a portion of a site prior to completion of decommissioning for the entire site, based on the risks associated with the early partial site release (see Appendix K).

- NRC staff supports a risk-informed graded approach for engineered barriers, and this guidance includes an example of how the risk-informed approach is applied to designing erosion protection barriers (see Section 3.5). In addition, the staff supports a risk-informed graded approach for selecting institutional controls and for long-term monitoring and maintenance at restricted use sites, which allows licensees to tailor the type of institutional controls and the specific restrictions on future site use based on a risk framework and insights from dose assessments (see Section 17.7 of Vol. 1, Rev. 1).

New to NUREG-1757, Vol. 2, Section 2.8, "Flexibility for Use of Institutional Controls and Engineered Barriers at Restricted Use Sites"

2.8 FLEXIBILITY FOR USE OF INSTITUTIONAL CONTROLS AND ENGINEERED BARRIERS AT RESTRICTED USE SITES

The new guidance developed for restricted use sites includes risk-informed and performance-based approaches to institutional controls, engineered barriers, monitoring, and maintenance. These approaches not only enhance the attention to safety by being risk-informed, but also provide flexibility to licensees planning restricted use for a site. The approaches described allow licensees to select the most effective and efficient methods for: restricting site use; designing engineered barriers to mitigate disruptive processes important to compliance; and planning monitoring and maintenance activities that are tailored to the specific site and indicators of potential disruptive processes and engineered barrier performance. These approaches are described in Section 17.7 and Appendix M of Vol. 1, Rev. 1.

New to NUREG-1757, Vol. 3, Chapter 8, "Returning, Canceling, or Reducing Financial Assurance Instruments"

8 RETURNING, CANCELING, OR REDUCING FINANCIAL ASSURANCE INSTRUMENTS

When licensees replace financial instruments, the superceded instruments should be canceled and returned to the licensee. Likewise, when licenses are terminated, or licenses fall below the possession limit thresholds requiring financial assurance, the instruments should be canceled and returned to the licensee. As an alternative, at the request of the licensee, the superceded or canceled financial instrument may be sent directly to the issuer.

Note that financial instruments are amended or revised from time to time. An amendment or revision to an existing instrument generally does not require cancellation and return of the earlier versions to the licensee.

The regulations of Parts 30, 40, 70, and 72 provide no method to credit work completed during decommissioning against the amount of financial assurance provided. Therefore, to reduce the amount of financial assurance, the licensee must either amend its license to reduce its possession limits, amend its decommissioning cost estimate to reflect the actual cost remaining to complete decommissioning, or terminate its license.

Where the licensee provides financial assurance for a prescribed amount, based on its license possession limits, the financial assurance must be maintained in accordance with the license possession limits until the license is terminated. In this case, the financial assurance instrument may not be returned until after the license is terminated. The amount of financial assurance may not be reduced unless the license is amended to reduce the possession limits to permit either (1) use of a lower prescribed amount of financial assurance or (2) elimination of the financial assurance requirement. However, the licensee has the option to provide financial assurance using a DFP, with the amount based on a site-specific cost estimate. If the licensee exercises that option, it may reduce or cancel its financial assurance as described below.

Where the licensee provides financial assurance using a DFP based on a site-specific decommissioning cost estimate, the amount of financial assurance must cover the amount of the last approved cost estimate. Therefore, the licensee can reduce its financial assurance by submitting a revised DFP and receiving NRC approval. The licensee may not reduce its decommissioning cost estimate simply by subtracting the cost of work completed from the last approved cost estimate. In order to reduce the amount of financial assurance provided, the licensee must submit a new cost estimate, acceptable to the NRC, which justifies a lower amount based on the cost of work remaining to be done. If the licensee has completed all decommissioning activities and surveys, it may submit a cost estimate of zero, which will permit cancellation of its financial assurance instruments when the cost estimate is accepted by the NRC.

Changes to
NUREG-1757, Vol. 1, Rev. 1,
Section 5.2, “Decommissioning Process”

5.2 DECOMMISSIONING PROCESS

The decommissioning process consists of a series of integrated activities, beginning with the licensee notifying NRC and changing the licensee's program from "active" to "decommissioning" status, and concluding with the termination of the license and release of the site pursuant to 10 CFR 30.36(k), 40.42(k), 70.38(k) or 72.54. Depending on several factors, including the type of license, the use of radioactive material at the facility, or past management of radioactive material at the facility, the decommissioning may be either relatively simple and straightforward or complex.

While the steps may vary for different sites, the basic process is the same. Figure 5.2 illustrates the steps in a flow chart format, showing licensee and NRC actions. The steps in the process are as follows:

- Stop operations, either in a specific area or building (see Chapter 15.5 for a discussion on partial site decommissioning) or for the entire facility.
- Notify NRC of the decision within 60 days.
- Determine locations and concentrations of remaining radiological contamination.
- If necessary, develop a DP (see Figure 5.3) that includes all of the following:
  - the current radiological contamination at the site;
  - the criteria for the final condition of the site;
  - the activities to remediate existing contamination that are not currently authorized by the license;
  - procedures to protect workers;
  - decommissioning cost estimates;
  - the final survey method to demonstrate compliance with NRC criteria; and
  - provides the schedule for remediation activities and license termination.
- If necessary, provide environmental information on NEPA Compliance as described in Section 15.7.
- Clean up contamination, as needed.
- Conduct Final Status Survey to show compliance with dose limits for license termination.
- Request that NRC terminate the license.

Note that it is important for licensees to notify NRC promptly when operations cease. It is also important that the staff meet with the licensee to discuss the decommissioning requirements early in the process.

In 2002, NRC and EPA entered into a Memorandum of Understanding (MOU) entitled, "Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites." The MOU continues the 1983 EPA policy that EPA will defer Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authority at NRC-licensed sites that are decommissioned, unless otherwise requested by NRC. The MOU identifies the criteria under which NRC will consult with EPA on sites undergoing decommissioning under NRC authority and outlines the process under which NRC will consult with EPA. The intent of the process established under the MOU is to minimize the occurrence of so called "dual regulation," where EPA is required to respond under CERCLA to conditions at a site cleaned up to the radiological criteria for license termination in 10 CFR Part 20, Subpart E. The MOU is included as Appendix H in this Volume.

Figure 5.2a The Decommissioning Process (1 of 2).

[Figure 5.2a not modified and not included in this draft.]

Figure 5.2b The Decommissioning Process (2 of 2).

[Figure 5.2b not modified and not included in this draft.]

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11. ABSTRACT *(200 words or less)*

In September 2003, the U.S. Nuclear Regulatory Commission (NRC) published a three-volume NUREG report, NUREG-1757, "Consolidated NMSS Decommissioning Guidance." NUREG-1757 provides guidance on: planning and implementing license termination under the License Termination Rule (LTR) in 10 CFR Part 20, Subpart E; complying with the radiological criteria for license termination; and complying with the requirements for financial assurance and recordkeeping for decommissioning and timeliness in decommissioning of materials facilities.

This draft supplement to NUREG-1757 is the first of periodic updates to the three volumes of NUREG-1757, to reflect current NRC decommissioning policy. NUREG-1757, Supp. 1, provides draft guidance for addressing the following LTR Analysis issues, which were explored by the NRC staff in Commission papers: restricted use and institutional controls; onsite disposal of radioactive materials; scenario justification based on reasonably foreseeable land use; intentional mixing of contaminated soil; and removal of material after license termination. It also provides new and revised guidance to address several other issues. This draft is published for public comment. Please submit comments by December 30, 2005.

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