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Revision 0

Comparison of Selected DOE and Non-DOE Requirements, Standards, and Practices for Low-Level Radioactive Waste Disposal

Radioactive Waste Technical Support Program

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Comparison of Selected DOE and Non-DOE Requirements, Standards, and Practices for Low-Level Radioactive Waste Disposal

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ABSTRACT

This document results from the Secretary of Energy's response to Defense Nuclear Facilities Safety Board Recommendation 94-2. The Secretary stated that the U.S. Department of Energy (DOE) would "address such issues as...the need for additional requirements, standards, and guidance on low-level radioactive waste management." The authors gathered information and compared DOE requirements and standards for the safety aspects of low-level radioactive waste disposal with similar requirements and standards of non-DOE entities.

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TABLES

ACRONYMS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
CFR	Code of Federal Regulations
CH-TRU	contact-handled TRU
DAS	Deputy Assistant Secretary
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
EIS	Environmental Impact Statement
ERDA	Energy Research and Development Administration
FR	Federal Register
GTCC	greater-than-Class C
HLW	high-level waste
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
INEL	Idaho National Engineering Laboratory
LLW	low-level radioactive waste
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
PA	performance assessment

PRP	peer review panel
PSO	Program Secretarial Officer
RADWASS	Radioactive Waste Safety Standards
RH-TRU	remote-handled TRU
RWMC	Radioactive Waste Management Complex
SLLW	solid low-level waste
TRU	transuranic
WIPP	Waste Isolation Pilot Plant

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1. INTRODUCTION

In 1988, the U.S. Congress established the Defense Nuclear Facilities Safety Board (DNFSB) to provide independent oversight relative to the design, construction, operation, and decommissioning of certain defense nuclear facilities of the U.S. Department of Energy (DOE). On September 8, 1994, the DNFSB issued Recommendation 94-2, "Conformance with Safety Standards at DOE Low-Level Nuclear Waste and Disposal Sites." In response, by letter dated October 28, 1994, the Secretary of Energy accepted Recommendation 94-2 and stated that the DOE would "address such issues as ... the need for additional requirements, standards and guidance on low-level radioactive waste management."

On March 31, 1995, the Secretary of Energy issued the DNFSB Recommendation 94-2 Implementation Plan, which outlines the actions DOE will take to respond to the recommendations. Section VI of the Implementation Plan commits DOE to perform several tasks, one of which is Task B.6, "Review Commercial and International Standards and Requirements and Compare to DOE Standards and Requirements."

This report was prepared to fulfill task VI.B.6. To accomplish this, contributors gathered information and compared DOE requirements and standards for the safety aspects of the disposal of low-level radioactive waste (LLW) with similar non-DOE requirements and standards, and highlighted the differences. The non-DOE requirements are those applicable to licensees of the Nuclear Regulatory Commission (NRC) or Agreement States. These facilities are generally located on government-owned land and operated by commercial entities. This report is not intended to offer a judgment about whether one method is better than another.

In comparing regulatory systems the term "standards" cannot easily be distinguished from the term "requirements." Therefore, to avoid confusion, the term "standards" is not normally used in this document. For purposes of this document, "requirements" include both mandated actions and standards imposed by DOE-Headquarters (DOE-HQ), the NRC, or Agreement States. The term "practices" refers to the approaches taken by individual DOE field offices or by state licensees to meet technical requirements. An example of a practice is the use of a specific computer code (in lieu of others that are available) for performance assessment work to calculate dose to the most exposed individual.

The scope of the review includes the comparison of safety-related topics found in the following types of documents:

- NRC regulations and guidance
- Agreement State requirements

- DOE orders and guidance
- Non-DOE license conditions and requirements
- Disposal facility waste acceptance criteria
- International programs such as the International Atomic Energy Agency (IAEA) Radioactive Waste Safety Standards (RADWASS)
- Site-specific performance assessment (PA) documents.

Section 2 of this report provides background information and a brief history of NRC and DOE LLW disposal activities. Section 3 describes the method used for selecting the topics for comparison and the criteria for identifying differences. Section 4 summarizes the differences that were found by comparing the requirements, guidance, or practices for the different topics. The appendices contain more detailed comparisons from which many of the differences were derived. Some of the differences were observed while reviewing documents such as disposal facility licenses and publications discussing disposal practices at facilities outside the United States.

Information on IAEA requirements, guidance, and practices was obtained by review of a list of IAEA documents from an IAEA Order Form for Radioactive Waste Management Publications, dated January 1995. Twelve older IAEA documents (dated 1965 to 1989) were obtained locally and reviewed. These consisted of eight Safety Series, two Technical Report Series, and proceedings from two symposia. The authors decided that appropriate documents for use in this report would come from the RADWASS series of international consensus documents, which are designed to make more evident the agreements by member countries regarding approaches to establishing safety. Of 24 planned RADWASS documents that might have been appropriate for this comparison, only two were available, *Classification of Radioactive Waste, A Safety Guide*, Safety Series No. 111-G-1.1, dated 1994,[1] and *Siting of Near Surface Disposal Facilities*, Safety Series No. 111-G-3.1, dated 1994.[2] Some information from these two documents was used in this report. Other RADWASS documents are currently pending approval or scheduled for later publication.

2. HISTORY OF U.S. GOVERNMENT REGULATION OF RADIOACTIVE MATERIALS

The first major use of radioactive material was by the Manhattan Engineering District whose single purpose was to develop and produce a useable nuclear weapon. Waste management activities were driven by the existing knowledge of radiological health and safety hazards, with consideration for the urgency of the national defense project. Sites and contractors developed waste management programs largely in isolation both from each other and from headquarters control.

The Atomic Energy Act of 1946 transferred Manhattan Engineering District facilities and responsibilities to the civilian-controlled Atomic Energy Commission (AEC). The Act stressed that the Commission's paramount objective remained "assuring the common defense and security." In the early days, the AEC allowed contractors to establish waste management standards, usually following consultation with AEC staff. The AEC guidelines limited exposure of employees to the maximum permissible levels recommended by the National Committee on Radiation Protection. Offsite exposures were to be held to one tenth to one hundredth of the maximum permissible limits. Low-level wastes were often diluted and dispersed to the environment because it was assumed that they presented no serious hazard. High-level waste (HLW) was considered the major waste problem and these wastes were concentrated and contained.

AEC licensing and regulatory oversight of organizations outside the agency that possessed nuclear materials began with the growth in civilian uses of nuclear materials. Regulation was necessary to control the distribution of nuclear materials and to ensure that organizations outside the AEC that managed these materials adhered to the safeguards observed within the agency.

In response to increased commercial use of nuclear materials, the AEC announced in 1960 that regional land disposal sites for commercially generated LLW should be established by the private sector. The disposal sites would be located on government-owned land (Federal or state) and would be licensed and regulated by the AEC. The announcement roughly coincided with the establishment of the Agreement State program, under a 1959 amendment to the Atomic Energy Act of 1954. Under the program, states with regulatory programs substantially equivalent to those of the AEC could assume licensing and regulatory authority over most categories of radioactive materials owners, other than nuclear power reactors and the AEC itself.

The AEC required Agreement States to adopt waste disposal regulations which were compatible with those of the AEC. Beyond this, the states were given authority to develop supplementary requirements and guidance consistent with the framework of the disposal regulations. While states were empowered to develop their own guidance, for practical reasons most have chosen to adopt, formally or informally, the technical guidance developed by the staff and contractors of the AEC and its successor agencies.

The Energy Reorganization Act of 1974 split the AEC into two organizations, the Energy Research and Development Administration (ERDA) and the NRC. The ERDA was directed to continue the Federal government's programs for management of nuclear-related programs for research and development and national defense. ERDA was later eliminated and its functions were absorbed by the Department of Energy, which was created by the Department of Energy Organization Act of 1977.

The Reorganization Act assigned to the NRC responsibility for regulating organizations outside ERDA that possess nuclear materials. The Reorganization Act limited NRC's licensing authority to only selected ERDA facilities. Congress intended that defense-related ERDA activities be self-regulated by ERDA because national defense is the responsibility of the federal government, not the states. NRC/state licensing activities were primarily intended to impose a regulation system for independent private contractors of nondefense-related nuclear activities. At that time, because of the common origin, the standards that were to be enforced by the NRC against licensees were essentially those that had been developed by the old AEC.

Although the NRC and DOE were no longer under the same managerial umbrella, cooperation and technical consultation continued. The NRC has called upon the system of national laboratories, mostly under DOE management, to conduct many of the technical studies related to pathway analysis, computer code development, engineered barriers analysis, and other technical issues that have provided the knowledge base for the development of the NRC's regulations for LLW disposal. Thus, both agencies essentially draw from the same pool of technical data in the development of requirements and standards. Because of the different circumstances and needs of commercial and defense facilities, the regulatory approach taken by the NRC and DOE has diverged over the years. These approaches are discussed in the sections that follow.

2.1 NRC Approach to Regulating LLW Disposal

Largely due to problems encountered at some of the early commercially-operated disposal facilities (Maxey Flats, West Valley, and Sheffield), the NRC in the late 1970s and early 1980s established a comprehensive regulatory framework for LLW disposal, codified as Title 10 of the Code of Federal Regulations (CFR), Part 61. The Environmental Impact Statement (EIS) for the regulations[3] provides the rationale for their development:[a]

> Current NRC regulations for licensing radioactive materials do not contain sufficient technical standards or criteria for the disposal of licensed materials as waste. Comprehensive standards, technical criteria, and licensing procedures are needed to ensure the public health and safety and long-term environmental protection in the licensing of new disposal sites. They are also needed with respect to operation of the existing sites and with respect to final closure and stabilization of all sites. The development of these regulations has been in response to needs and requests expressed by the public, Congress, industry, the states, the commission and other federal agencies for codification of regulations for the disposal of LLW.

In developing the rule, the NRC considered several alternative approaches and decided upon one that included both performance objectives and prescriptive technical requirements. A system limited to detailed technical requirements was rejected because it might "discourage use of new or creative solutions to waste disposal problems."[4] The NRC also believed that such requirements might need to be revised frequently in response to improvements in waste form and disposal technologies. For this

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a. Reference 3 is the NRC's final EIS. Reference 4 is the draft EIS. The NRC chose not to revise large sections of the draft for inclusion in the final revision; therefore, both the draft and the final EIS were issued. This report quotes material from both revisions.

reason, the technical requirements included in the regulation, except those addressing waste classification, were worded in a general, qualitative manner. The NRC also rejected the option of limiting regulatory requirements to performance objectives. As stated in the Draft EIS for Part 61:

> Development of purely performance objective requirements, while workable, would not allow for establishment of more detailed prescriptive requirements in those areas where specific guidance is known to be needed. In this rulemaking effort, NRC thus plans to establish overall performance objectives or standards of performance that should be achieved in the disposal of LLW, minimum technical performance requirements that should be considered in all cases in the disposal of LLW and where possible, detailed prescriptive requirements. Subsequent to this rulemaking, NRC plans to publish regulatory guides in the areas of waste form, site suitability and design and operations which will provide detailed prescriptive guidance.[4]

Primary among the NRC performance objectives is a requirement that the site not release radioactive material into the environment in concentrations that would result in an annual dose equivalent[b] to any member of the general population exceeding 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ (10 CFR 61.41). To demonstrate that the site meets the performance objective, NRC expects that computer models will be used that make use of specific assumptions about the disposed waste, the location of the most exposed individual with respect to the disposal site, and the pathways that migrating radionuclides might take to reach this individual.

While the NRC's technical requirements are generally qualitative, the regulations establish specific and quantitative requirements with regard to the concentration limits allowed in waste disposed of in near-surface facilities (10 CFR 61.55). The rationale for uniform waste classification tables applicable to all NRC near-surface disposal facilities is based on exposure to a hypothetical future "inadvertent intruder" who excavates directly into the waste disposal units. Under the scenario, the dose equivalent to the intruder depends primarily on the concentration of radionuclides, the waste form itself, and the depth of burial.

The intruder dose equivalent is relatively independent of site-specific factors, including the size of the site, total site radiological inventory, environmental conditions, and physical site characteristics. For this reason, the NRC elected not to include specific performance objectives addressing radiation exposures to a hypothetical inadvertent intruder. In place of that performance objective, technical requirements were imposed in Subpart D of 10 CFR 61 requiring use of the NRC waste classification system and stabilization requirements. Requirements for either a minimum disposal depth (five meters for Class C waste) or an engineered intruder barrier are prescribed by 10 CFR 61.52.

The NRC used 500 mrem/yr as the dose equivalent limit for scenarios involving a hypothetical inadvertent intruder. The concentration limits for class A waste were set so that the intruder would not exceed the dose equivalent limit under a number of scenarios involving direct excavation into the waste. The NRC increased this concentration limit by a factor of 10 for Class C waste because of the lower probability of the intruder coming into contact with the waste, primarily because of its burial at additional depth or engineered intrusion barriers.

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b. See discussion and definition of the term "dose equivalent" in Section 4.6.

Although inadvertent intrusion was the de facto basis for the classification system, it was not the driving force behind the regulation. The highest priorities were to minimize radioactive releases to the environment and to minimize the need for active disposal facility maintenance following closure. To accomplish these goals, the NRC imposed generic structural stability requirements on higher activity wastes (classes B and C) realizing that these waste classes contain approximately 95 percent of the radioactivity in commercial LLW. The regulation left room for disposal facilities to impose additional stabilization requirements as needed for site-specific considerations.

The approach of using both technical requirements and performance objectives is intended to promote the safety of the operating disposal facility and, in some cases, to prescribe defense-in-depth design requirements for the facility. Defense-in-depth design requirements include waste form stabilization requirements that provide radionuclide migration barriers independent of the site geological characteristics. Technical requirements beyond those prescribed in 10 CFR 61, such as inventory limits, are sometimes imposed as administrative license conditions to ensure that the facility performs in accordance with the Part 61 performance objectives. The technical requirements outlined in 10 CFR 61, Subpart D include:

- Disposal site suitability requirements
- Site design requirements
- Operational requirements
- Closure requirements
- Requirements for waste classification
- Prohibitions and limits related to the form of the waste
- Environmental monitoring
- Institutional requirements.

2.2 DOE Approach to Regulating LLW Disposal

The DOE's policies and guidelines for managing the Department's LLW were formally established in February 1984 with the publication of DOE Order 5820.2, *Radioactive Waste Management*. This order replaced the policies of the AEC that had evolved over the years. In 1986 DOE initiated a revision of DOE Order 5820.2, Chapter III, Management of Low-Level Waste. DOE established a working group to draft a prescriptive or performance objective-oriented revision of the LLW chapter of the order. DOE-HQ expanded this initiative and issued formal direction to rewrite the entire order. The revision was intended to address the requests of disposal site operators that DOE Order 5820.2 should establish more definitive requirements, such as generation, characterization, acceptance criteria, treatment, shipment, storage, and disposal of waste, and disposal site closure, environmental monitoring, quality assurance, and records and reports.

In early 1987, as part of the order revision process, DOE considered establishing a LLW classification system for inclusion in the revised order. Consideration was given to establishing Class I, II, and III limits based primarily on hypothetical inadvertent intruder exposures. A waste classification table was developed and later revised by DOE-HQ to address NRC concerns that the draft DOE dose limits were different from those of the NRC, thereby putting two agencies in differing public positions. The revised table did not cover all radionuclides reported as significant by the major DOE waste disposal sites, particularly uranium, thorium, and radium. This created problems for DOE sites because the radionuclides listed in the table more closely represented waste streams from commercial reactors than those in DOE waste streams.

Although there was much support for establishing a DOE waste classification system, the system was not adopted. (Reference 5 gives more details of the 1987 effort to establish a waste classification system and more fully explains the reasons why a DOE-specific waste classification system was not used.) A reference to the greater-than-Class C (GTCC) waste classification found in the NRC regulations is included in DOE Order 5820.2A, which requires that the DOE equivalent of that waste be handled as special case wastes. Disposal of these wastes in near-surface facilities must be justified by a waste-specific PA through the National Environmental Policy Act (NEPA) process with concurrence from designated DOE-HQ officials.

The revised DOE Order (5820.2A) was approved on September 26, 1988, and is currently in use. The DOE elected to establish a functional performance objective to limit the effective dose equivalent[c] to a hypothetical inadvertent intruder. Engineered modifications (stabilization, packaging, burial depth, and barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, and radium) are developed through the performance assessment model. In the course of this process, site-specific waste classification limits are developed, if they are found to be operationally useful in determining how specific wastes should be stabilized. Thus, any waste acceptance criteria and associated waste form requirements found necessary to limit individual or hypothetical inadvertent intruder exposure are established on a site-specific basis, and are based on calculations of dose under a credible, worst-case, site-specific scenario.

DOE established functional criteria (performance objectives) in DOE Order 5820.2A for each site to use as the basis for design and operation of LLW disposal sites. The performance objectives include public exposure and environmental release limits and allowable effective dose equivalent limits for a hypothetical inadvertent intruder. Primary among the DOE performance objectives is a requirement that the site not release radioactive material into the environment in concentrations that would result in an annual effective dose equivalent exceeding 25 mrem to any member of the general population. Releases to the atmosphere must meet the requirements of 40 CFR 61. The order also includes the following performance objective for the inadvertent intruder: "Assure that the committed effective dose equivalents received by individuals who may inadvertently intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure." Like the NRC, the DOE inadvertent intruder performance objective is based on a hypothetical scenario, not an expected scenario. The scenario is intended to be used as a design mechanism to ensure that disposal facility designers provide defense-in-depth design

c. See discussion and definition of the term "effective dose equivalent" in Section 4.6.

considerations regarding long-term waste stability. The waste should provide acceptable characteristics under potential future environmental and administrative control conditions.

To demonstrate that the site meets the performance objectives, each site is directed by the order to prepare and maintain a site-specific radiological PA for the disposal of waste with the purpose of demonstrating compliance with the performance objectives. Guidance for preparation of DOE performance assessments is provided by a Performance Assessment Task Team established by DOE-HQ. A formal review of the PA is performed by a DOE-HQ established PA Peer Review Panel prior to being submitted to DOE-HQ for authorization for disposal. The Order requires sites to use monitoring measurements, where practical, to evaluate actual and prospective performance and to evaluate and modify the models used in the PA.

DOE Order 6430.1, *General Design Criteria*, was updated in April 1989 to include design requirements that support DOE Order 5820.2A, including guidelines for siting and design of LLW disposal facilities. The order reinforces the requirement that LLW disposed underground should be confined by a site-specific system of barriers that take into account waste form, waste packaging, and geologic setting. The order emphasizes that means be provided to minimize contact of emplaced LLW with water.

Like the NRC, DOE uses both prescriptive technical requirements and performance objectives to establish "defense-in-depth" barriers in the disposal system. Performance objectives and technical requirements for LLW disposal are found in DOE Order 5820.2A, Chapter III. DOE has issued a number of documents that identify applicable prescriptive requirements for LLW disposal operations. These include environmental impact statements, PAs, safety analysis reports, technical safety requirements, and waste acceptance criteria. The following is a list of significant LLW disposal topics and the DOE order(s) in which applicable requirements can be found:

- Disposal site suitability requirements—DOE Order 5820.2A, *Radioactive Waste Management* and DOE Order 6430.1A,[d] *General Design Criteria*

- Site design requirements—DOE Order 5820.2A, *Radioactive Waste Management* and DOE Order 6430.1A, *General Design Criteria*

- Operational requirements—DOE Order 5820.2A, *Radioactive Waste Management* and DOE Order 5480.19, *Conduct of Operations Requirements For DOE Facilities*

- Closure requirements—DOE Order 5820.2A, *Radioactive Waste Management*

- Requirements for waste classification—DOE Order 5820.2A, *Radioactive Waste Management*

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d. At the time of this writing, DOE is implementing two new orders, DOE Order 420.1, *Facility Safety*, and DOE Order 430.1, *Life Cycle Asset Management*, which will supersede DOE Order 6430.1A. DOE Order 6430.1A is applicable to all DOE sites until the site contracts are changed to reflect the new orders. The new orders contain no specific design requirements for LLW disposal facilities.

- Prohibitions and limits related to the form of the waste—DOE Order 5820.2A, *Radioactive Waste Management*

- Environmental monitoring—DOE Order 5820.2A, *Radioactive Waste Management*, DOE Order 6430.1A, *General Design Criteria*, DOE Order 5400.1, *General Environmental Protection Program*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*

- Institutional requirements—DOE Order 5820.2A, *Radioactive Waste Management*.

3. METHODOLOGY FOR COMPARISONS

A DNFSB report, *Low-Level Waste Disposal Policy for Department of Energy Defense Nuclear Facilities*,[6] organized radioactive waste disposal into five functional areas. These five areas and two additional categories (PA and approval requirements) were used as a basis for organizing the discussion of safety-related areas. The seven functional areas are siting, design, operations, closure, waste form, PA and approval requirements. Topics to be considered for comparison were then chosen for each of these functional areas. (An expanded listing of the topics is shown in Appendix A.) Disposal facility performance objectives are covered under the PA functional area.

The comparison was performed as two principal tasks:

1. Reviewing and listing for comparison the LLW disposal requirements, guidance, and practices of DOE, the U.S. non-DOE LLW disposal industry, and selected international documents.

2. Identifying differences in the requirements, guidance, and practices that may affect public or worker health and safety.

It was not practical to perform comparisons among all types of documents in the same way. Some comparisons were made line-by-line, using a recognized standard such as 10 CFR 61 as the primary reference. Others involved comparing requirements of various documents (such as facility waste acceptance criteria) for pre-established topics and looking for trends or gaps in the documents. Still other situations called for reading significant reference documents such as NRC Branch Technical Positions and acknowledging noteworthy practices for discussion in this report. Differences were identified when a requirement, guideline, or practice appeared different than another or if the comparison was complex enough to require further study.

The core requirements document for U.S. non-DOE LLW disposal operations is 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Wastes." This Federal regulation establishes procedures, criteria, and terms and conditions upon which the NRC would issue licenses for the disposal of LLW. Similar requirements from 10 CFR 61 and DOE documents are grouped side by side and discussed in Appendix B of this report. The differences are addressed in Section 4 of this report. The main DOE document used for comparison is DOE Order 5820.2A.

Recently, memoranda have been issued by DOE-HQ that also apply to changes being made to DOE policy and requirements in response to the DNFSB Recommendation 94-2. A memorandum from the Deputy Assistant Secretary for Waste Management, Environmental Management,[7] requires LLW PAs to include pre-1988 source terms and other sources of radioactive contamination in their analysis. Another memorandum, which establishes an interim DOE policy on oversight of LLW management and disposal,[8] was issued by the Assistant Secretary for Environmental Management and the Assistant Secretary for Environment, Safety, and Health.

A comparison of waste acceptance criteria for the existing Barnwell and Richland non-DOE disposal facilities and for four DOE disposal facilities is shown in Appendix C. Topics used in the

comparison were taken from a previous work,[9] which compared the waste acceptance criteria of existing, former, and proposed non-DOE disposal facilities.

Appendix D contains DOE and non-DOE PA information gathered to determine if there are any differences in requirements, guidance, and practices. The information was separated into six tables:

- Table D-1—DOE PA requirements and guidance
- Table D-2—Non-DOE PA requirements and guidance
- Table D-3—DOE PA practices at the INEL's Radioactive Waste Management Complex (RWMC) and Hanford's 200 West Area
- Table D-4—DOE PA practices at Oak Ridge National Laboratory's (ORNL's) SWSA 6 and the Savannah River Site's E-Area Vaults
- Table D-5—Non-DOE PA practices in Texas, California, and Nebraska
- Table D-6—Non-DOE PA practices in North Carolina, Washington, and South Carolina.

The DOE PA documents used were those that have been completed in at least a draft form and reviewed by the PA Peer Review Panel. Most of these documents have not been approved. Because the work is continuing, the information is subject to change.

4. DIFFERENCES IN REQUIREMENTS, GUIDANCE, AND PRACTICES BASED ON COMPARISONS

This section provides descriptions of apparent differences between DOE and non-DOE requirements, guidance, and practices for disposal of LLW. The authors have purposefully avoided drawing conclusions or making judgments or recommendations concerning if and how differences should be resolved, since that task is reserved for planned follow-on efforts. The differences are discussed under the following seven functional areas used to select safety-related topics: siting, design, operations, closure, waste form, PA, and approval and oversight.

4.1 Siting

Table B-1 in Appendix B compares the NRC siting requirements from 10 CFR 61 with those from DOE Orders 5820.2A and 6430.1A. The criteria for siting disposal facilities are similar; however, DOE is more constrained on potential site locations than commercial disposal facilities. The DOE disposal siting options are constrained by the locations of current DOE reservations, which were deemed as "appropriate" sites for nuclear activities at the time they were selected from national candidate sites. Non-DOE facilities generally begin site selection within the geographic boundaries of an entire state.

Since DOE establishes waste acceptance criteria for its sites on a site-specific basis, it has flexibility to restrict disposal of certain kinds of wastes from a disposal site if the site-specific PA concludes that the waste cannot be safely disposed at that site. For example, the INEL RWMC disposal facility will not accept LLW for disposal if it contains greater than 10 nCi/gram transuranic activity. Non-DOE sites are sited to accept all class A, B, and C standardized waste forms. Thus, the DOE has more flexibility than the NRC to deem a disposal site as acceptable by imposing a site-specific restrictive waste acceptance criteria.

The document *Comparative Approaches to Siting Low-Level Radioactive Waste Disposal Facilities*[10] details the methods used by the various states to select site locations for disposal facilities. Most often these have included top-down screenings in which land area is eliminated from consideration in step-wise fashion by applying data that represent pre-established site selection criteria. Potential sites are those that remain after all the criteria have been applied. However, the report expresses reservations about these kinds of processes. Because top-down screening processes are presented as rigorous and scientific, shortcomings in the amount and quality of available screening data and professional differences over the importance of various site requirements have often been used to discredit the results. This then becomes a political as well as technical problem. Several non-DOE sites that have tried top-down screenings without success are now attempting more collaborative approaches to site selection. DOE has recently successfully faced the siting of new disposal facilities at sites such as the Hanford Environmental Remediation Disposal Facility with a public participation and review process involving a future land use planning activity. Future public participation in DOE activities may increase the level of attention to these issues.

4.2 Design

Within and outside of DOE, a variety of designs are contemplated or in use for LLW disposal facilities. Tables 1 and 2 show current and planned disposal methods for DOE and non-DOE existing and planned facilities. As the tables show, disposal methods vary from traditional shallow land burial (open trench disposal) to use of near-surface disposal methods that utilize engineered barriers (such as vaults) to provide "greater confinement" for LLW disposal.[e] The tables show that both non-DOE and DOE facilities utilize design concepts that incorporate engineered barriers to provide greater confinement of radionuclides beyond the confinement afforded by the waste form and site geologic characteristics. The use of the greater confinement barriers seems to be prevalent at more humid disposal sites.

Despite the favorable natural characteristics associated with several of the operating sites, most states have prohibited the use of shallow land burial techniques for future sites. The state prohibitions on shallow land burial are primarily intended to make the facilities more publicly acceptable.[11] Nebraska's law, for example, provides that:

> No license for the operation of a facility shall be granted to any applicant who proposes a disposal design which uses traditional shallow land burial as used prior to 1979. The disposal cells of the facility shall be built above grade levels and designed to meet the state's zero-release objectives. (Nebraska Low-Level Radioactive Waste Disposal Act, Act 81-15, Section 101.02)

Other states that prohibit shallow land burial or that require the use of engineered barriers include Connecticut, New York, Pennsylvania, Ohio, North Carolina, and Illinois. Beginning in January 1996 South Carolina will also require vaults or equivalent barriers at the Barnwell disposal site.

Although the requirements of 10 CFR 61 were based on a hypothetical near-surface disposal facility in a humid environment, the NRC has maintained that the performance objectives and technical requirements in the regulation can be applied to a variety of disposal designs so long as the design objectives of 10 CFR 61 are met. In June 1993, the NRC amended 10 CFR 61.7 to state:

> near-surface disposal includes disposal in engineered facilities which may be built totally or partially above-grade provided that such facilities have protective earthen covers.

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e. The term "shallow land burial" refers to past methods of LLW waste disposal in which waste was placed in excavated pits or trenches and backfilled, capped, and mounded to facilitate water runoff. This method did not include use of engineered structures such as concrete vaults or concrete containers to provide additional confinement barriers to waste migration.

As defined in 10 CFR 61.7(a), "near-surface disposal" is a more encompassing term that includes both shallow land burial and engineered disposal facilities that may be built totally or partially aboveground, provided that such facilities have protective earthen covers. By definition these facilities must also involve disposal within the upper portion of the earths crust, approximately 30 meters.

Table 1. DOE low-level waste disposal facility descriptions.[a]

DOE site	Current disposal method
Hanford	
Low-Level Burial Grounds	Shallow land burial (V-trenches, wide bottom trenches)
Grout (emergency use only, planned vitrification facility replacement	Near-surface concrete vaults
Idaho National Engineering Laboratory	Shallow land burial (pits, trenches, soil vaults)
Nevada Test Site	
Area 3	Shallow land burial in subsidence craters from underground nuclear tests
Area 5	Shallow land burial (pits, trenches, boreholes)
Los Alamos National Laboratory	
MDA G	Shallow land burial (pits, 20-meter deep disposal shafts)
Oak Ridge Reservation	
Solid Waste Storage Area 6	Above-grade tumulus
Savannah River Site	
Saltstone	Grout in above-grade vaults (covered with soil, clay, and gravel earthen cap)
E-Area Vault	Above-grade concrete vaults (covered with soil, clay, and gravel earthen cap)

a. Source of table information: *Framework for DOE Low-Level and Mixed Waste Disposal: Current Overview*, DOE/ID-10484, June 1994.

Table 2. Non-DOE current and planned low-level waste disposal facility descriptions.

Non-DOE site	Current or planned disposal method
California	Shallow land burial in trenches at additional depth with 5 meters of fill over top of waste
Nebraska	Above ground, earth-mounded concrete bunker
North Carolina	Above-grade, earth-mounded concrete vaults
South Carolina	Shallow land burial in trenches with waste in concrete overpacks
Texas	Shallow land burial in trenches with all waste in modular concrete containers
Washington	Shallow land burial in trenches

Thus, designers of facilities that must comply with state and NRC requirements have latitude in the design of engineered barriers for LLW disposal facilities. The PA, which is a part of the license application, documents that the overall disposal system, including the disposal facility, the site, and the waste form, meet regulatory performance objectives.

DOE also takes a non-prescriptive approach to setting disposal barrier requirements. Specific DOE LLW disposal facility design requirements are found in DOE Order 6430.1A. This order states that LLW that is disposed underground shall be confined by a site-specific system of barriers that may include, but not necessarily be limited to, waste form, waste packaging, and the geologic setting. Technical design personnel establish the detailed barrier requirements necessary to meet the performance objectives established in DOE Order 5820.2A. Compliance with DOE performance objectives is documented in the facility PA.

A significant difference between the DOE and the non-DOE LLW disposal design approaches is the fact that the NRC requires use of an LLW classification system and associated stability and disposal segregation requirements in 10 CFR 61, while DOE considers these as design parameters to be established on a site-specific basis. (Waste form requirements are further discussed in Section 4.5.)

The NRC requires that non-DOE disposal facilities dispose of Class C waste "so that the top of the waste is a minimum of 5 meters below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years" [10 CFR 61.52(a)(2)]. This requirement results from the fact that the waste classification and waste form stabilization requirements were driven by intruder scenario assumptions that included a five-meter burial depth assumption. The NRC did not establish a minimum depth requirement for Class A or B wastes.

The DOE did not establish a minimum depth requirement for its waste. The design of the method of waste stabilization, packaging, burial depth, and engineered barriers and covers for specific waste types and specific waste compositions is required to be developed through the PA on a site-specific basis. Some DOE sites require a minimum five-meter depth for higher activity wastes based on PA results.

4.3 Operations

A detailed comparison of disposal site operations, which might include staffing, dosimetry, emergency response, contingency plans, and other operational practices is beyond the scope of this report. Two aspects of site operations where differences between DOE and non-DOE practices are most apparent, recordkeeping and reporting and requirements for preventive measures in the event that radionuclide migration is detected, are discussed in the following paragraphs.

Subpart G of 10 CFR 61 contains fairly detailed requirements for maintenance of records and reports for non-DOE LLW disposal operations. DOE Order 5820.2A, Chapter III, Section 3m, contains some less prescriptive information on maintenance of records for DOE LLW operations. Reporting requirements for environmental monitoring, similar to those in 10 CFR 61, Subpart G, are found in DOE Order 5400.1, Chapter II, Section 4. The DOE 1324 series of orders provided details

on records management requirements for the DOE system. Therefore, the system of DOE orders provides similar requirements for records and reports as 10 CFR 61.

The DOE 1324 series of orders were recently reformatted and consolidated into one order, DOE Order 1324.5B, Records Management Program, dated January 12, 1995, whose only requirement for the heads of field elements is that they "shall develop and implement a records management program consistent with the requirements of Federal law, Code of Federal Regulations, DOE directives, DOE guidelines, and Departmentally established or accepted referenced standards." They must also "ensure that all records management program requirements are kept current and available for review." These requirements are not as prescriptive as the LLW recordkeeping requirements found in 10 CFR 61, which prescribe such things as acceptable record form (electronic, microform, or original records).

Unlike non-DOE operations [10 CFR 61.53(b)], DOE does not require the disposal facility to maintain plans for preventive measures if migration of radionuclides indicates that the performance objectives are not being met. DOE Order 5820.2A, Section 3k(4), requires that the monitoring program be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives.

4.4 Closure

DOE Order 5820.2A, Section 3j(1) states, "Field organizations shall develop site-specific comprehensive closure plans for new and existing operating LLW disposal sites. The plans shall address closure of disposal sites within a 5 year period after each disposal site is filled." In Section 3j(6), the Order states that termination of monitoring and maintenance activities at closed facilities shall be based on an analysis of site performance at the end of the institutional control period (normally 100 years). Thus, DOE takes the position that maintenance and monitoring of the site will be available, as necessary, until the end of the institutional control period. DOE is silent on passive controls after the institutional control period in DOE Order 5820.2A, but the Performance Assessment Task Team recommends that each analyst state and justify such a period on a site-specific basis.[5]

This approach is different from the NRC requirement in 10 CFR 61.29, which states that: "Following completion of closure authorized in Part 61.26, the licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the license is transferred by the Commission in accordance with Part 61.30. Responsibility for the site must be maintained by the licensee for 5 years. A shorter or longer time period for post-closure observation and maintenance may be established and approved as part of the site closure plan, based on site-specific conditions." Text in 10 CFR 61.7(c)(3) makes it clear that the five-year post-closure observation and maintenance period ensures that the disposal site is stable and ready for institutional control.

At the end of this five-year period, the licensee applies for a transfer of the license to the disposal site owner (a Federal or state agency). Transfer of the license requires that any funds and necessary records for care will be transferred to the disposal site owner [10 CFR 61.30(3)]. Thus, it is the position of the NRC that maintenance of the site during the institutional control period should not be necessary but would be performed as required. The planned period of institutional control is determined by the state; it cannot be less than 100 years. Active institutional controls may not be relied upon to limit access by the public to the site for over 100 years (10 CFR 61.59). Following the

institutional control period the license is terminated by the Commission and permanent monuments or markers warning against intrusion are installed. Passive barriers are designed to protect against inadvertent intrusion for at least 500 years (10 CFR 61.52).

4.5 Waste Form

4.5.1 Waste Stabilization

One difference was found in the emphasis placed by the NRC and DOE on waste stabilization. DOE Order 6430.1A places primary confinement reliance on the geological properties of the site and augments these with waste form characteristics and engineered barriers, as necessary. Thus, DOE establishes waste form stabilization requirements based on site-specific technical analysis and PA. The NRC has taken the position that waste form should play a significant role in the overall plan for managing LLW and requires that some wastes have structural stability, independent of any site-specific considerations. 10 CFR 61.56(b)(1) states that structural stability can be provided by the waste form itself, by processing the waste to a stable form, or by placing the waste in a disposal container or structure that provides stability after disposal. The NRC *Technical Position on Waste Form*[12] describes acceptable methods of accomplishing waste stability, which includes mandatory stabilization of Class B and C wastes and the use of high-integrity containers. Thus, the primary difference is that the NRC imposes mandatory waste form stability requirements on all disposal sites, while DOE imposes stability requirements on a site-specific basis, as deemed necessary by technical analysis.

State agencies that regulate non-DOE LLW disposal have adopted the practice of approving the use of specific products as part of the operating licenses for disposal facilities.[13,14,15] These include solidification, stabilization, sorbent media, and waste containers (including high-integrity containers). Some DOE sites specify approved products and processes for solidification, stabilization, or absorbent media in their waste acceptance criteria.

In a comparison of waste acceptance criteria of DOE and NRC facilities (see Appendix C), the authors noted that state licensed facilities typically impose waste form requirements on incinerator ash as a licensing condition (no NRC requirement was found regarding incinerator ash or particulate immobilization requirements). It was also noted that the NRC has stability requirements for dewatered resins which are typically imposed as a license condition. Some DOE site waste acceptance criteria do not specifically address stability requirements for these two waste forms, which may be less common among DOE waste streams. The observation seems to be consistent with the DOE practice of establishing waste form stability requirements based on site-specific concerns.

4.5.2 Waste Classification

The NRC subclassifies LLW into Class A, B, or C (see 10 CFR 61.55). LLW that exceeds Class C levels is considered generally unsuitable for near-surface disposal by both DOE and the NRC. These classifications are used to determine the relative short- and long-term hazards of the waste form and as a basis for establishing stabilization requirements.

DOE Order 5820.2A specifies that disposition of waste designated as greater-than-Class C (as defined in 10 CFR 61.55), must be handled as special cases. Disposal systems for such waste must be

justified by a specific PA, through the NEPA process, and with the concurrence of DOE-HQ. As a result of this requirement no DOE LLW disposal site is disposing of any DOE-equivalent GTCC waste.

DOE Order 5820.2A also designates that waste with transuranium radionuclides in concentrations of greater than 100 nCi/gram shall be designated as transuranic (TRU) waste; all DOE TRU waste will be placed in interim storage and, later, disposed of in a deep geologic disposal facility, the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The DOE does not specify subclasses of LLW on a standardized or system-wide basis, as is done in the NRC Class A, B, C system. However, LLW classification requirements may be imposed by each DOE site in their waste acceptance criteria. Each site implements requirements for waste classification as deemed necessary to segregate the waste so that handling, stabilization, and disposal requirements can be imposed to meet disposal performance objectives. For instance, Hanford classifies its LLW as Category 1 or 3 wastes based on an activity limits table; Category 3 waste requires stabilization. The waste acquisition criteria for Savannah River E-Area vaults places isotope-specific limits on waste received by the facility. Oak Ridge SWSA-6 requires that generators identify and segregate waste into categories that include fissile waste material (based on a isotope limit table), very low activity waste, contact-handled solid low-level waste (SLLW), remote-handled SLLW, biological waste, asbestos waste, and naturally occurring and accelerator-produced radioactive material. The IAEA safety guide on classification of radioactive waste (see Reference 1) provides recommendations for a classification system based on safety-related aspects of radioactive waste disposal, which is similar to the approach taken by the NRC and specific DOE sites.

A comparison of DOE, NRC, and IAEA classification systems is shown in Table 3. The IAEA and NRC classification systems have the following features that are not formally required by DOE:

- The Class A, B, and C designations used by the NRC provide a basis for categorizing waste according to relative short- and long-term hazards, based on activity levels and half-lives of radioactive constituents. Some DOE facilities use a similar classification system.

- The IAEA classification uses a designation of intermediate-level to indicate if the container's radiation exposure rate is greater than 200 mrem/hr at contact. This practice is similar to that for DOE TRU waste, where the waste is designated as remote-handled TRU (RH-TRU) and contact-handled TRU (CH-TRU). All DOE LLW disposal facilities use a radiation limit to differentiate between remote-handled or contact-handled LLW, but there is no formal recognition of the practice in the DOE orders.

- The IAEA classification uses a thermal power level (2 kW/m^3) quantitative discriminator to differentiate between LLW and HLW. Federal Law defines HLW for the NRC and the DOE.

Non-DOE LLW disposal sites are required to use the NRC classification system to establish waste stabilization requirements (10 CFR 61.55 and 56). Although not required, some DOE sites have designated and use a site-specific LLW classification system. DOE Order 5820.2A, Section 3i(2), states that site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.

Table 3. Comparison of DOE, NRC, and IAEA waste classification systems.

IAEA		DOE		NRC		
Waste class	Typical characteristics	Waste class	Typical characteristics	Waste class	Typical characteristics	Comments
Exempt Waste	Activity levels below clearance levels based on an annual dose to public <0.01 mSv (1 mrem).	Nonradioactive waste	No volume contamination added by nuclear operations. Surface contamination levels for release of materials are provided in DOE 5400.5, Figure IV-1 and the contamination must be subjected to the ALARA process. There is no guidance for release of volume contaminated material. Such material may be released if criteria and survey techniques are approved by EH-1.	Exempt waste	The NRC has exempted certain non-DOE products from disposal as LLW, but does not have generally applicable standards for evaluating requests for exemptions.	None
LLW—Short Lived	Long-lived alpha-emitting radionuclides <4,000 Bq/g (108 nCi/g) in individual waste packages and <400 Bq/g (11 nCi/g) overall average. No shielding required for normal handling and transportation.	LLW	Waste that is not HLW or TRU waste.	Low-level Class A, B, or C waste	Waste with radionuclide concentrations corresponding to levels given in Tables 1 and 2 of 10 CFR 61.55.	Neither DOE nor NRC classification identifies the contact gamma radiation levels of the LLW package as done by the IAEA. The DOE classification for TRU waste, and some DOE LLW sites, includes a remote- or contact-handled designator to indicate the shielding and special handling considerations associated with the waste package. The radiation level of the package gives some relative indication of the gamma activity in the package.
LLW—Long Lived	Long-lived alpha-emitting radionuclides >4,000 Bq/g (108 nCi/g) in individual waste packages and >400 Bq/g (11 nCi/g) overall average. No shielding required for normal handling and transportation.	CH-TRU	>100 nCi/g TRU waste activity. Contact dose rate <200 mrem/hr—no shielding required for normal handling and transportation. Some DOE facilities also manage waste containing other alpha radionuclides as TRU waste.	Greater-Than-Class-C waste	Waste with radionuclide concentrations exceeding the levels given in Table 1 of 10 CFR 61.55 and is not generally acceptable for near-surface disposal.	

Table 3. (continued).

IAEA		DOE		NRC		
Waste class	Typical characteristics	Waste class	Typical characteristics	Waste class	Typical characteristics	Comments
Intermediate Level Waste—Short Lived	Long-lived alpha-emitting radionuclides <4,000 Bq/g (108 nCi/g) in individual waste packages and <400 Bq/g (11 nCi/g) overall average. Contact dose rate >200 mrem/hr—shielding required for normal handling and transportation. Thermal power <2 kW/m^3.	LLW	Waste that is not HLW or TRU waste.	Low-level Class B or C waste	Waste with radionuclide concentrations corresponding to levels given in Tables 1 and 2 of 10 CFR 61.55.	Many DOE sites impose site-specific classification systems which quantify the long- and short-term hazards of its LLW.
Intermediate Level Waste—Long Lived	Long-lived alpha-emitting radionuclides >4,000 Bq/g (108 nCi/g) in individual waste packages and >400 Bq/g (11 nCi/g) overall average. Contact dose rate >200 mrem/hr—shielding required for normal handling and transportation. Thermal power <2 kW/m^3.	RH-TRU	>100 nCi/g TRU waste activity. Contact dose rate >200 mrem/hr—shielding required for normal handling and transportation.	Greater-Than-Class-C waste	Waste with radionuclide concentrations exceeding levels given in Table 1 of 10 CFR 61.55 and is not generally acceptable for near-surface disposal.	
HLW	Thermal power >2 kW/m^3. Long-lived alpha-emitting radionuclides >4,000 Bq/g (108 nCi/g) in individual waste packages and >400 Bq/g (11 nCi/g) overall average.	HLW	Waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.	HLW	(1) Irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first-cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.	The DOE and NRC do not have a quantitative value, such as the 2 kW/m^3 level, to designate the point when waste is no longer considered HLW.

4.6 Performance Assessment

The comparisons of the PA requirements, guidance, and practices are shown in Appendix D. The comparison tables provide a summary of the requirements and guidelines of the NRC. They also provide supplemental information of PA practices in Texas, California, Nebraska, North Carolina, and Washington. Of these facilities, only the Richland, Washington, facility is currently operating. The Barnwell, South Carolina, non-DOE facility is also an operating disposal site; however, detailed information from that site was not supplied for this report. The DOE disposal facilities covered are located in Idaho, Washington, South Carolina, and Tennessee.

Differences in the PA requirements, guidance, and practices of DOE and non-DOE disposal facilities are as follows:

1. Approval of the PA for new non-DOE disposal facilities is part of the license application review process. DOE Order 5820.2A does not specify processes for approving and maintaining PAs. However, an interim DOE policy on oversight of LLW management and disposal, issued on July 21, 1995 (see Reference 8), provides specific procedures for approval of PAs and issuance of disposal authorization statements that set requirements for ensuring compliance with LLW disposal facility performance objectives.

2. The NRC and DOE use different dose systems in regulating potential radiation exposures of members of the public and hypothetical inadvertent intruders from disposal of low-level waste. The NRC uses the so-called critical organ approach to dose limitation recommended in Publication 2 of the International Commission on Radiological Protection (ICRP).[17] In this approach, limits on dose equivalent[f] are established for the whole body and the critical organ, which usually is the organ receiving the highest dose. Thus the NRC expresses its performance objective for members of the public from low-level waste disposal in terms of limits on dose equivalent of 25 mrem per year to the whole body, 75 mrem per year to the thyroid, and 25 mrem per year to any other organ. The NRC also used higher dose limits to the whole body and the critical organ in establishing its waste classification system for near-surface disposal, which is intended to provide protection of hypothetical inadvertent intruders. However, the DOE uses the more recent approach to dose limitation recommended in ICRP Publication 26,[18,19] in which limits on dose equivalent to the whole

f. Dose equivalent is defined as the product of absorbed dose in rad (or gray) in tissue and a quality factor which takes into account differences in biological effectiveness between different types of radiation.. Dose equivalent is expressed in units of rem (or sievert).

body and the critical organ are replaced by a single limit on effective dose equivalent.[g,h] Thus, for members of the public, the DOE's performance objective for low-level waste disposal is expressed as a limit on effective dose equivalent of 25 mrem per year, and higher limits on effective dose equivalent also are used in the performance objective for protection of hypothetical inadvertent intruders.

3. Non-DOE PAs are not required to include calculations of dose to a hypothetical inadvertent intruder as is required of DOE PAs. The NRC does not require these calculations because the NRC waste classification system (waste Classes A, B, and C) is based on calculations of dose for a hypothetical inadvertent intruder scenario. DOE Order 5820.2A, Chapter III, Section 3b(1), requires the PA to include calculations of effective dose equivalents to the inadvertent intruder to demonstrate compliance with the performance objectives given in DOE Order 5820.2A, Chapter III, Section 3a(3).

4. The NRC uses an allowable chronic dose equivalent limit to the inadvertent intruder of 500 mrem/yr to the whole body and bone or 1.5 rem/yr to any other organ, to establish concentration limits for LLW placed in near surface disposal facilities (see Reference 4). The DOE uses an allowable chronic effective dose equivalent of 100 mrem/yr for DOE site-specific inadvertent intruder calculations [DOE Order 5820.2A, Chapter III, Section 3.a(3)]. The NRC increased the calculated upper limit for Class C waste by a factor of 10 to allow for disposal of waste packages with above average concentrations of nuclides. This was done for consideration of peak-to-average waste concentrations and the low probability of contacting the higher concentration waste. When calculating the dose to the inadvertent intruder the DOE PAs assume that the buried waste is homogeneously mixed. There is no DOE policy or guidance (for a site that develops a site-specific waste classification system) to allow the use of a similar factor of 10 to establish the maximum concentration of a radionuclide that may be disposed.

5. The NRC requires that non-DOE disposal facilities protect an inadvertent intruder from coming into contact with disposed Class C LLW with an intruder barrier or a 5-meter cover [see 10 CFR 61.52(a)(2)]. DOE establishes barrier requirements based on engineering calculations made in the PA. DOE Order 5820.2A, Section 3i(2), states that engineered modifications for specific waste types and compositions for each disposal site shall be developed through the PA model.

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g. Effective dose equivalent is defined as the sum over specified tissues of the products of the dose equivalent in a tissue (T) and the weighting factor for that tissue (w_T), i.e., $H_E = \Sigma\, w_T H_T$. The effective dose equivalent is the sum of the effective dose equivalent received from external exposure, which normally is essentially the same as the dose equivalent to the whole body, and the committed effective dose equivalent from internal exposure. The weighting factors w_T are specified in ICRP Publication 26 and are intended to be proportional to the risk of stochastic health effects (i.e., fatal cancers or severe hereditary effects) per unit dose equivalent in the specified tissues. Thus, effective dose equivalent is intended to be proportional to stochastic risk for either uniform or non-uniform irradiations of the whole body. Effective dose equivalent is expressed in units of rem (or sievert).

h. DOE Order 5820.2A incorrectly specifies limits on "committed effective dose equivalent" for exposures of inadvertent intruders, which would exclude external dose. The Performance Assessment Task Team identified this problem and has provided guidance that the allowable doses are to be expressed as effective dose equivalents (see Reference 5).

6. Neither the NRC nor DOE has established specific guidance on estimating inventories of previously buried wastes (although these wastes must be included in PAs) or on how to proceed in the event that credible estimates are not possible. This promises to be an issue because of the recent DOE memorandum (see Reference 7) that requires inclusion of pre-1988 waste in the PA source term.

4.7 Approval and Oversight

Differences exist between DOE and non-DOE LLW disposal facilities in the processes by which operational approval is granted and adherence to requirements is ensured.

4.7.1 Operational Approval

For the purposes of this report, operational approval is defined as the official authorization for a proposed facility to begin accepting waste for disposal or for an existing facility to continue accepting waste. Official authorization to operate implies a chain of organizational responsibility for the decision. Outside DOE, states may elect to become Agreement States by establishing regulatory programs functionally equivalent to those of the NRC. These programs are subject to periodic audit by the NRC; during these audits any shortcomings are noted and required to be corrected.

4.7.1.1 Approval for Construction. Before construction of a new non-DOE disposal facility may begin, a license application must be filed and a license obtained for the facility. The license application must contain specific technical information outlined in 10 CFR 61.10. The application must undergo a comprehensive review by the NRC or Agreement State agency to confirm that the proposed facility is expected to meet performance objectives and technical requirements in the 10 CFR 61 regulations. These reviews can take several years and cost several million dollars. Because the application review process is extensive, states invariably rely on the services of specialized contractors to make recommendations in areas that require detailed scientific and technical analysis.

The license is issued by the governing agency after a finding that the issuance of the license will not be inimical to the common defense and security and will not constitute unreasonable risk to the health and safety of the public, and provided that all standards established in 10 CFR 61.23 are satisfied. If the NRC were to issue a license rather than an Agreement State, the NRC would have to prepare an EIS in accordance with 10 CFR 51, Subpart A; the EIS assesses the impacts of a decision to approve the application. Some Agreement States also have statutes requiring an EIS for LLW disposal activities.

The operational approval process for proposed DOE LLW disposal facilities has some elements in common with the state processes. DOE Order 5820.2A requires field organizations with disposal sites to prepare and maintain a site-specific radiological PA for the disposal of waste with the purpose of demonstrating compliance with the radiological performance objectives in the order. For new DOE LLW disposal facilities, PAs are reviewed by the responsible field element and submitted to the Deputy Assistant Secretary (DAS) for Waste Management before construction begins. Recent DOE guidance (see Reference 8) establishes policy for review and approval of disposal facility PAs, which are reviewed by a peer review panel (PRP) at the request of the DAS for Waste Management. The purpose of this review is to ensure consistency and technical quality throughout the DOE complex in the development and application of performance assessment models that include site-specific

geohydrology and waste composition. The PRP is selected by the DAS for Waste Management and is composed of DOE, contractor, and other specialists in PAs, with participation by representatives of the Office of Environment, Safety, and Health, and operations offices.

Documentation from the PRP review accompanies the PA, as well as other information, as needed, that assesses disposal facility performance (such as the closure plan and safety analysis report for the disposal facility). Waste Management staff evaluate the PA and PRP reviews, consult with the Office of Environment, Safety, and Health; and make a recommendation to the Assistant Secretary For Environmental Management regarding compliance with the performance objectives of DOE Order 5820.2A. The Assistant Secretary for Environmental Management decides whether or not to authorize construction of the disposal facility. When construction is authorized, the DAS for Waste Management prepares a Disposal Authorization Statement that sets forth the conditions for design, construction, and operation of the disposal facility that are appropriate to ensure compliance with the LLW performance objectives.

DOE contractors are also required to obtain the Program Secretarial Officer (PSO) approval of Preliminary Safety Analysis Reports (PSARs) prior to undertaking procurement of materials and components, construction, and preoperational testing of DOE nuclear facilities.[20] The PSAR is a document routinely prepared to document the adequacy of the safety basis for a new nuclear facility; it provides assurance that the facility can be constructed, operated, maintained, and shut down safely and in compliance with applicable laws and regulations. It differs from the PA in that it primarily deals with worker and public safety issues during routine and credible off-normal operational conditions, whereas the PA is concerned with providing a reasonable estimate that the facility will meet the performance objectives established in DOE Order 5820.2A.

4.7.1.2 Approval for Disposal. The operator of a state- or NRC-licensed facility may begin operations after construction if it meets all of the conditions and requirements of its license. The agency issuing the license has the right to perform inspections of the wastes, equipment, operations, and facilities and to have any tests performed that it deems appropriate or necessary for the administration of the regulations. The agency may obtain an injunction or other court order to prevent a violation of requirements in applicable acts, rules, regulations, and license conditions.

DOE contractors are required to submit the facility's Final Safety Analysis Reports (FSARs) to the PSO for approval and authorization to operate DOE nuclear facilities. This approval is required in addition to the approval of the PA and PSAR prior to the start of facility construction. FSARs document the adequacy of the safety basis and provide assurance that the facility can be operated, maintained, and shut down safely and in compliance with applicable laws and regulations.[20] The National Environmental Policy Act Implementing Procedures (10 CFR 1021) requires DOE to normally prepare an EIS for all major system acquisitions posing a potential threat to the environment. Thus, the LLW disposal facility operation will be addressed by a sitewide or a site-specific EIS. Both the NRC and DOE requirements for an EIS implement Section 102(2) of NEPA. The DOE EIS process requires public hearings. The EIS is ultimately approved by DOE.

Startup and restart of DOE LLW disposal facilities requires the successful completion of an operational readiness review (ORR) as outlined in DOE Order 425.1, *Startup and Restart of Nuclear Facilities* (supersedes DOE Order 5480.31, *Startup and Restart of Nuclear Facilities*). The ORR consists of both a contractor review and a DOE review of the facility's readiness to operate. Upon

completion of the ORR, a final report documents the results of the ORR and reaches a conclusion as to whether startup of the facility can proceed safely. Thus, the issuance of a Disposal Authorization Statement, approval of the FSAR, approval of an applicable EIS, and a favorable ORR are the equivalent of the non-DOE facility licensing process. A primary difference between the DOE and commercial facility operation is that the commercial license process is conducted and approved by an independent state or Federal agency, while the DOE operational approval is given by DOE, which is also responsible for operation of the facility.

4.7.1.3 Applicability of New Requirements to Existing Facilities. Another point of comparison is the applicability of newly adopted rules and requirements to LLW disposal facilities already operating. When 10 CFR 61 was issued in late 1982, three non-DOE-operated, state-licensed facilities had been operating for a number of years under pre-existing requirements. The "Statements of Consideration" that accompanied the final issuance of 10 CFR 61 (47 *FR* 57446, December 27, 1982) indicate that most of the rule was meant to apply to the pre-existing disposal sites:

> (A comment received on the draft rule) touches upon a subject with broader implications, the phasing in of the Part 61 requirements, consistent with the ability of licensees, Agreement States, and applicants to make necessary changes to assure compliance.
>
> The following sections and subparts will be considered a matter of compatibility for the Agreement States when the rule is adopted: Section 61.2, Definitions; Subpart C, Performance Objectives; Subpart D, Technical Requirements for Land Disposal; those portions of Subpart B that are necessary to implement the provisions of Subparts C and D; Subpart E requiring closure funding arrangements; and Section 20.311, Transfer for disposal and manifests...

Some technical issues related to applying the new rule do not appear to have been explicitly addressed. Prior to issuance of the rule there were no standard regulatory limits on the concentration level of radioactive waste that could be accepted for disposal (i.e., the classification tables in 10 CFR 61.55). Because of this, waste found to be generally unsuitable for near surface disposal, because it would yield unacceptable doses to an inadvertent intruder (500 mrem/yr dose equivalent), had already been disposed in the pre-existing trenches. However, an environmental analysis of the Barnwell, South Carolina, facility done by the NRC in 1981, determined that doses to the most exposed member of the public from the site would be well within 15 mrem per year dose equivalent in spite of the presence of waste exceeding near-surface disposal limits.[16] Richland, Washington has included its pre-1982 wastes in the performance assessment submitted with its closure plan currently in the review and approval process.

The issuance of DOE Order 5820.2A in 1988 raised similar issues of retroactivity within the DOE system. The order required that each disposal site meet an effective dose equivalent limit to a hypothetical member of the public, although the form and composition of waste in the earlier years of disposal were not required to meet the same criteria for acceptance. Moreover, detailed information about the characteristics of waste was not available to calculate such doses to the level of confidence generally expected by today's standards. DOE intended that pre-1988 waste would be dealt with under Comprehensive Environmental Response, Compensation, and Liability Act; therefore, DOE Order 5820.2A stated that "waste that has not been disposed of prior to issuance of this Order shall be

managed on the schedule developed in the Implementation Plan to accomplish the following: ..." A recent DOE memorandum (see Reference 7) that requires inclusion of pre-1988 waste in the PA source term has been issued.

4.7.2 Regulatory Oversight

There are differences in the processes by which DOE and non-DOE LLW disposal facilities ensure ongoing compliance with regulations and guidance. Once a non-DOE disposal facility begins operating, the state agency that regulates the facility has authority to impose sanctions (including civil and criminal penalties or facility shutdown) in the event that noted deficiencies are not corrected. These are usually in the form of monetary fines or outright cancellation of the operator's privilege to accept waste. Under provisions of the NRC Agreement State Program, the state radiation protection programs are subject to periodic audit by the NRC to ensure that they are compatible with the NRC's own programs and that their programs and staff are sufficient. The failure to correct any deficiencies noted can result in forfeiture of the state regulatory functions back to the NRC, although no such remedy has been invoked in the 30-year history of the program.

Disposal facilities are subject to regulation and oversight by various DOE offices. The Deputy Assistant Secretary for Waste Management (EM-30) is charged with carrying out Assistant Secretary for Environmental Management (EM-1) responsibilities for managing DOE waste management activities, developing and interpreting waste management policy, and issuing guidance to the field. The Assistant Secretary for Environment, Safety, and Health (EH-1) provides oversight and independent assessments of waste management operations. EM and EH offices are organizationally independent, but both report to the Secretary of Energy. EM-30 requirements are implemented in the waste management facilities by DOE management and operating contractors through written operating procedures and documented training programs. DOE field office representatives oversee the contractor operations and utilize a system of contractor incentive fees to encourage compliance with requirements. EH-1 and EM-1 have shutdown authority for waste management operations if environment, safety, and health risks are judged to be unacceptable.

The DOE is presently assessing the appropriateness of continued self-regulation and the need for external regulation. The outcome of the DOE review of external regulation options and a DOE strategic alignment may impact the alternatives DOE will actually implement over the long term. The evaluation is being performed by the Advisory Committee on External Regulation of DOE Nuclear Safety. The committee is co-chaired by John Ahearne, Executive Director of Sigma Xi, the Scientific Research Society, and former Chairman of the NRC; and Gerald Scannell, President of the National Safety Council and former Assistant Secretary of Labor for the Occupational Safety and Health Administration. It consists of 25 members from five Federal agencies, state regulators, public interest groups, and nuclear utilities. The final report is scheduled to be released by the end of calendar year 1995.

4.7.3 Other Approvals

A non-DOE license establishes a list of requirements that must be met to operate the facility. The DOE has multiple activities and documents that are designed to perform the same functions as the licensing process. These include preparing and gaining approval of the safety analysis report, technical safety requirements, PA, site monitoring plan, NEPA documentation, and operations procedures, and conducting an operational readiness review before beginning operations.

Table 4 shows approval authority requirements for various documents that must be completed before disposal operations can begin at DOE and U.S. non-DOE LLW disposal sites. The required documentation is grouped into categories, based on the function of the document. The table shows that DOE has approval authority of most of the documents, excluding Federal regulations. In both the DOE and non-DOE approval processes, the acceptance of the final product depends on technical justification. DOE operations are currently subject to some Federal regulations; however, a majority of DOE requirements are found in DOE orders. From the table, it can be concluded that DOE operations are largely self-governed and regulated while U.S. non-DOE disposal operations are governed and regulated by independent agencies of the Federal or state governments. Efforts are underway to codify many of the DOE orders. The codification of the orders makes DOE operations subject to civil and criminal penalties if requirements of the Federal regulations are not met.

Table 4. Categories of documentation for LLW disposal facilities.

Category	Category description	Non-DOE requirements document	Approval level	DOE requirements document	Approval level
A	Federal and state regulations and standards	Code of Federal Regulations, state regulations	Federal or state	DOE Orders, Code of Federal Regulations, state regulations	Federal, state, or DOE
B	Required safety envelope reviewed and imposed by regulating bodies	License	State	PA, safety analysis report, technical safety requirements, NEPA documentation (EIS), Operational Readiness Review (DOE Order 425.1), DOE Interim Policy (Reference 8)	DOE
C	Technical assessment	License application technical review	State	PA	DOE
D	Technical considerations	NRC guidance documents, NRC technical position papers, state guidance	State	DOE guidance documents	DOE
E	Safety envelope implementation	Waste acceptance criteria, standard operating procedures	Private operating facility contractor	Waste acceptance criteria, standard operating procedures	DOE operating facility contractor

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Appendix A

Safety Related Topics for Comparison

Appendix A

Safety Related Topics for Comparison

I. Approval and Oversight

II. Siting

- A. Siting considerations
- B. Site characterization

III. Design

- A. Facility design and construction
  - a. Engineered cover
  - b. Drainage system
  - c. Intruder barriers

IV. Operations

- A. Waste inspection and verification
- B. Waste emplacement
  - a. Stacking
  - b. Compacting
  - c. Separation of waste classes
- C. Environmental monitoring
- D. Corrective measures
  - a. Required notifications for unusual occurrences
  - b. Operational startup/shutdown approval authority
- E. Records, reports, tests, and inspections

V. Closure

- A. Facility closure/institutional control

VI. Waste Form

A. Waste classification system

B. Waste characteristics

a. Waste acceptance criteria
b. Waste characterization
c. Waste certification

C. Waste form and packaging

a. Waste stabilization
b. Acceptable packaging
c. Prohibited wasteforms

VII. Performance assessment

A. General

a. Format and content

1. What are the general format and content of the performance assessment?

b. Approval process

1. What is the formal process for final approval of the performance assessment?

c. Review process

1. What formal review process does the performance assessment go through before submittal for approval?

d. Performance assessment maintenance

1. Does the performance assessment need to be reviewed and updated if parameters change?

e. Method for evaluating uncertainty

1. Is the method deterministic or probabilistic, and what kind of uncertainty or sensitivity analysis is used?

f. Computer codes

1. Is there an approval process for performance assessment codes that is separate from the performance assessment approval process?
2. Does the code approval process include validation and/or verification?

3. Is there a list of pre-approved codes?

B. Receptor (The topics and questions in this section apply to the most exposed individual. The same topics and questions are used in Section 3 as they apply to the inadvertent intruder.)

a. Receptor scenario

1. What general assumptions are required?
2. What site-specific assumptions are used?
3. Are variations used to model against possible future environmental conditions?

b. Dose standard

1. What is the dose standard (performance objective) for the most exposed individual?

c. Point of compliance

1. Where is the most exposed individual located with respect to the disposal site?

d. Time of Compliance

1. What is the time of compliance (time certain or peak dose)?
2. What assumptions are made about future land ownership/control?
3. What institutional control period is specified?
4. What assumptions are made about active and passive controls that may affect performance assessment results?

e. Dose conversion

1. What requirements or standards are used to determine dose conversion factors?

C. Receptor (The same questions used in Section 2 are repeated here, as they apply to the inadvertent intruder)

D. Release mechanism

a. Waste inventory

1. What are the requirements for keeping records on waste inventory?
2. How do current requirements for keeping records differ from past requirements?
3. Where past records are not up to today's standards, what is done to estimate waste inventory for purposes of the performance assessment?

b. Source term

1. What assumptions are made about the release of radionuclides from the various waste forms?
2. For purposes of the performance assessment during operations or for closure, is all waste included in the source term?

4.2.3 What is the source of scaling factors for indirectly measured radionuclides?

E. Pathways

a. Site characteristics

1. Must data about site characteristics meet any quality requirements in order to be used in the performance assessment?
2. What requirements are there to avoid the potential for "masking" from nearby facilities?

b. Waste distribution

1. What assumptions are made about the distribution of waste in disposal units for calculating dose to the most exposed individual?
2. What assumptions are made about the distribution of waste in disposal units for calculating dose to a hypothetical inadvertent intruder?

Appendix B

Comparison of NRC and DOE Disposal Requirements

Table B-1. Comparison of DOE and NRC disposal requirements.

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
License requirements	10 CFR 61.3(b)	Each person shall file an application with the Commission and obtain a license as provided in this part before commencing construction of a land disposal facility. Failure to comply with this requirement may be grounds for denial of a license.	DOE Order 5820.2A Chapter III 3.b.(1)	Field organizations with disposal sites shall prepare and maintain a site-specific radiological performance assessment for the disposal of waste for the purpose of demonstrating compliance with performance objectives.	The DOE disposal authorization statement is intended to serve a function similar to a license although the scope is not as broad. The DOE SAR, NEPA document, closure plan, and operational readiness reviews cover the remaining scope.
			Grumbly/ O'Toole Interim Policy Letter	Headquarters elements review and approve LLW disposal facilities performance assessments, and issue disposal authorization statements that set forth requirements important for assuring compliance with LLW disposal facility performance objectives.	
License requirements	10 CFR 61.6	The commission may, upon application by any interested person, or upon its own initiative, grant any exemptions from the requirements of the regulations in this part as it determines is authorized by law, will not endanger life or property, or ...	DOE Order 5480.31, 9.b(11)	There shall be a statement in each Operational Readiness Review (ORR) final report as to whether any identified nonconformances with compliance with applicable DOE Orders, Sec. of Energy Notices, and Standards/Requirements Identification Documents have been formally approved.	Both systems for operational approval require formal approval of exemptions from requirements.
Siting	10 CFR 61.7(a)	In choosing a disposal site, site characteristics should be considered in terms of the indefinite future and evaluated for at least a 500-yr time frame.	DOE Order 5820.2A, Chapter III 3i(7)(d)	The potential for natural hazards such as floods, erosion, tornadoes, earthquakes, and volcanoes shall be considered in site selection.	Both citations require consideration of long-term site characteristics.
Siting	10 CFR 61.7(a)	In choosing a disposal site, site characteristics should be considered in terms of the indefinite future and evaluated for at least a 500-yr time frame.	DOE Order 5820.2A, Chapter III 3i(7)(e)	Site selection criteria shall address the impact on current and projected populations, land use resource development plans and nearby facilities, accessibility to transportation routes and utilities, and the location of waste generation.	Both citations require consideration of long-term site characteristics.
Design	10 CFR 61.7(b)(1)	Disposal of radioactive waste in near-surface disposal facilities has the following safety objectives: (1) Protection of the general population from releases of radioactivity,	DOE Order 5820.2A, Chapter III 2a	DOE LLW operations shall be managed to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure that no legacy requiring remedial action remains after operations has been terminated.	The intent of the citations is the same.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.7(b)(1)	Disposal of radioactive waste in near-surface disposal facilities has the following safety objectives (2) Protection of individuals from inadvertent intrusion.	DOE Order 5820.2A, Chapter III 3a(3)	DOE LLW operations shall be managed to 3) Ensure that the committed EDEs received by individuals who inadvertently may intrude into the facility after the loss of active institutional control shall not exceed 100 mrem/yr for continuous exposure.	Both documents identify the need for protection of inadvertent intruders.
Design	10 CFR 61.7(b)(1)	Disposal of radioactive waste in near-surface disposal facilities has the following safety objectives (3) Protection of individuals during operations.	DOE Order 5480.23	All DOE operations must have approved safety analysis reports (SARs) which cover individual worker and public safety in detail.	The DOE system covers worker safety in great detail in their SARs.
Design	10 CFR 61.7(b)(1)	Disposal of radioactive waste in near-surface disposal facilities has the following safety objectives (4) Ensure stability of the site after closure.	DOE Order 5820.2A, Chapter III 3i(7)(d)	The potential for natural hazards such as floods, erosion, tornadoes, earthquakes, and volcanoes shall be considered in site selection.	Both citations address long-term stability. Waste form stability is specifically addressed in later requirements.
Design	10 CFR 61.7(b)(2)	The Class A waste will be disposed of in separate disposal units at the disposal site. However, Class A waste that is stable may be mixed with other classes of wastes. Those higher activity wastes that should be stable for proper disposal are classed as Class B and C waste.	DOE Order 5820.2A, Chapter III 3i(1) and (2)	(1) LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b. (2) Engineered modifications (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the PA. In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE determines allowable disposal practices for different types of waste on a case-by-case basis, as determined by the performance assessment. Waste classification is a site-specific requirement for DOE disposal sites.
Waste Form	10 CFR 61.7(b)(2)	To the extent that it is practicable, Class B and C waste forms or containers should be designed to be stable, i.e., maintain gross physical properties and identity over 300 yr.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE determines allowable disposal practices for different types of waste on a case-by-case basis, as determined by the facility design and performance assessment. Therefore, stability considerations of waste type disposal are considered.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.7(b)(2)	For certain radionuclides prone to migration, a maximum disposal site inventory based on characteristics of the disposal site may be established to limit potential exposure.	DOE Order 5820.2A, Chapter III 3e(5)	The waste acceptance criteria for storage, treatment, or disposal facilities shall address the following issues: (a) allowable quantities/concentrations of waste-specific radionuclides to be handled, processed, stored or disposed of; (b) ...	DOE determines allowable disposal practices for waste based on a case-by-case basis in the performance assessment. Therefore, allowable inventories for radionuclides will be established by the performance assessment.
Closure	10 CFR 61.7(b)(4)	Institutional control of access to the site is required for up to 100 yr. This permits the disposal of Class A and Class B waste without special provisions for intrusion protection, since these classes of waste contain types and quantities ...	DOE Order 5820.2A, Chapter III 3a(3)	DOE LLW ... shall be managed to (3) Ensure that the committed EDEs received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 yr) shall not exceed 100 mrem/yr.	The citations call for institutional control of the site for at least 100 yr after closure. The performance assessment will address the need for special provisions for intrusion protection after institutional controls are removed.
Waste Form	10 CFR 61.7(b)(5)	Waste that will not decay to levels which present an acceptable hazard to an intruder within 100 yr is designated as Class C waste.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE does not designate the Class C waste category but the performance assessment does look for long-term impacts on intruders. Waste classification is a site-specific criterion used if necessary to ensure containment of long-lived radionuclides and to assign unique intrusion barrier requirements.
Design	10 CFR 61.7(b)(5)	This waste is disposed of at greater depth than the other classes of waste so that subsequent surface activities by an intruder will not disturb the waste. Where site conditions prevent deeper disposal, intruder barriers such as concrete covers may be used. For Class C waste, where site conditions prevent deeper disposal, intruder barriers such as concrete covers may be used. The effective life of these intruder barriers should be 500 yr.	DOE Order 5820.2A, Chapter III 3i(2)	Engineered mods. (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the PA.	DOE does not designate the Class C waste category but the performance assessment does look for long-term impacts on intruders and necessary provisions are made for intrusion barriers. The design of intruder barriers at DOE facilities is based on performance assessment calculations and is specific for each site.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.7(b)(5)	Waste with concentrations above Class C limits is generally unacceptable for near-surface disposal.	DOE Order 5820.2A, Chapter III 3i(4)	Disposition of waste designated as Greater-Than-Class C (GTCC), as defined in 10 CFR 61.55, must be handled as special cases. Disposal systems for such waste must be justified by a specific performance assessment through the NEPA process and with the concurrence of DP-12 for all DP-1 disposal facilities and NE-20 for those disposal facilities under the cognizance of NE-1.	The 10 CFR requirement leaves room for exceptions to this rule. DOE prescribes methods for approving the exceptions.
Design	10 CFR 61.7(b)(5)	There may be some instances where waste with concentrations GTCC would be acceptable for near-surface disposal with special processing or design. These will be evaluated on a case-by-case basis.	DOE Order 5820.2A, Chapter III 3i(4)	Disposition of waste designated as GTCC, as defined in 10 CFR 61.55, must be handled as special cases.	Both requirements acknowledge the need for a case-by-case determination of the acceptability of the waste for near-surface disposal.
Waste Form	10 CFR 61.7(b)(5)	Class C waste must also be stable.	DOE Order 5820.2A, Chapter III 3i(2)	Engineered mods. (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the PA.	DOE addresses stability requirements base on performance assessment calculations.
Siting	10 CFR 61.7(c)(1)	During the preoperational phase, the potential applicant goes through a process of disposal site selection by selecting a region of interest, examining a number of disposal sites within the area and narrowing the choice to the proposed site.	DOE Order 5820.2A, Chapter III 3i(7)(a) and (b)	Disposal site selection criteria (based on planned waste confinement technology) shall be developed for establishing new LLW disposal sites. Disposal site selection shall be based on an evaluation of the prospective site in conjunction with planned waste confinement technology, and in accordance with the NEPA process.	Both statements acknowledge the need to examine multiple choices for the site selection.
Siting	10 CFR 61.7(c)(1)	Through a detailed investigation of the disposal site characteristics the potential applicant obtains data on which to base an analysis of the disposal site's suitability.	DOE Order 5820.2A, Chapter III 3i(8)(a)	Design criteria shall be established prior to selection of new disposal facilities, new disposal sites, or both. These criteria shall be based on analyses of physiographic, environmental, and hydrogeologic data to ensure that the policy and requirements of this Order can be met.	Both statements acknowledge the need for a detailed evaluation of the site characteristics to determine the site's suitability.
Siting	10 CFR 61.7(c)(1)	Through a detailed investigation of the disposal site characteristics the potential applicant obtains data on which to base an analysis of the disposal site's suitability.	DOE Order 5820.2A, Chapter III 3i(8)(a)	The criteria shall be also based on assessments of projected waste volumes, waste characteristics, and facility and disposal site performance.	Both statements acknowledge the need for a detailed evaluation of the site characteristics to determine the site's suitability.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
License Requirements	10 CFR 61.7(c)(1)	Along with these data and analyses, the applicant submits other more general information to the Commission in the form of an application for a license for land disposal.	Grumbly/ O'Toole Interim Policy Letter	Headquarters elements review and approve LLW disposal facilities PAs, and issue disposal authorization statement that set forth requirements important for assuring compliance with LLW disposal facility performance objectives.	DOE reviews the site-specific performance assessment to insure that the site will perform suitably.
Operations	10 CFR 61.7(c)(2)	During the operational phase, the licensee carries out disposal activities in accordance with the requirements of this regulation and any conditions on the license.	Grumbly/ O'Toole Interim Policy Letter	Field elements are required to implement the interim policy and ensure that LLW management activities are conducted in accordance with this policy.	The disposal authorization statement will set forth requirements important to achieving performance objectives.
			DOE Order 5480.22, 7.	It is the policy of the Department that facilities operate within PSO-approved Technical Safety Requirements (TSRs) which prescribe the bounds for safe operations of these facilities in order to protect the health and safety of the public and reduce risk to workers.	The DOE SAR process and the TSRs process establish the safety envelope and safety related requirements for operation of the facility. This is an equivalent to a license which also mandates essential requirements.
Operations	10 CFR 61.7(c)(2)	Periodically, the authority to conduct the aboveground operations and dispose of the waste will be subject to a license renewal, at which time the operating history will be reviewed and a decision made to permit or deny operation.	Grumbly/ O'Toole Interim Policy Letter	The Department can require shutdown of disposal operations based on failure to prepare an acceptable PA in a timely manner or to maintain an adequate PA maintenance program.	DOE requires periodic maintenance of the performance assessment.
			DOE Orders 5480.23 9.c, 5480.22 9.f	Contractors shall review and update SARs annually as necessary, ...to ensure the information is current and applicable. Contractors shall determine if revisions to the TSRs are necessary upon revision of the SAR.	The DOE has requirements to annually review the SAR and associated TSRs.
Closure	10 CFR 61.7(c)(2)	When disposal operations are to cease, the licensee applies for an amendment to his license to permit site closure.	DOE Order 5820.2A, Chapter III 3j(5)	Closure plans for new and existing operating LLW disposal facilities shall be reviewed and approved by the appropriate field organization	DOE facilities are closed according to requirements of approved closure plans. Closure activities will be performed under the provisions of an approved closure plan in accordance with DOE 5820.2A.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Closure	10 CFR 61.7(c)(2)	After review of the site closure and stabilization plan, the Commission may approve the final activities necessary to prepare the disposal site so that ongoing active maintenance of the site is not required during the period of institutional control.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The Nuclear Regulatory Commission (NRC) position seems to be that active maintenance should not be necessary during the institutional control period, and the DOE position is that it will be continued, as needed, until the end of the institutional control period.
Closure	10 CFR 61.7(c)(3)	Following the site closure phase, for a period of 5 yr, the licensee must remain at the disposal site for a period of post-closure observation and maintenance to ensure that the disposal site is stable and ready for institutional control.	DOE Order 5820.2A, Chapter III 3j(1)	The plan shall address closure of disposal sites within a 5-yr period after each is filled and shall conform to the requirements of the NEPA process.	Unlike the NRC, which seeks to verify that the site is stable within 5 yr after closure, DOE maintains a program of maintenance and monitoring on the site for the entire institutional control period (100 yr).
Closure	10 CFR 61.7(c)(3)	The Commission may approve shorter or require longer periods of closure observation and maintenance if conditions warrant.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	Similar to the NRC statement, the DOE routinely bases termination of observation and maintenance activities based on technical criteria.
Closure	10 CFR 61.7(c)(3)	At the end of the observation and maintenance period, the licensee applies for a license transfer to the disposal site owner.	N/A	N/A	The DOE is both the operator and site owner so the DOE equivalent to license transfer is final closure under an opproved closure plan.
Closure	10 CFR 61.7(c)(4)	Under the conditions of the transferred license, the owner will carry out a program of monitoring to ensure continued satisfactory disposal site performance, physical surveillance to restrict access to the site, and carry out minor custodial activities.	DOE Order 5820.2A, Chapter III 3k(1)	Each operational or non-operational LLW treatment, storage, and disposal facility shall be monitored by an environmental monitoring program that conforms with DOE 5484.1 and, at a minimum meets the requirements of para. 3k(2) through (4).	Both citations identify the need for an environmental monitoring plan.
Closure	10 CFR 61.7(c)(4)	At the end of the prescribed period of institutional control, the license will be terminated by the Commission.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activities at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The DOE has defined the point of termination of its activities for the disposal site, which is the equivalent of license termination.
License Requirements	10 CFR 61.10	An environmental report prepared in accordance with 10 CFR 51 Subpart A [NEPA-Regulations Implementing Section 102(2)] must accompany the license application.	10 CFR 1021.100	The purpose of 10 CFR 1021 is to establish procedures that the DOE shall use to comply with Section 102(2) of the NEPA of 1969 and the Council of Environmental Quality regulations for implementing procedural requirements of NEPA (40 CFR 1500-1508).	The DOE and the NRC implement the requirements of Section 102(2) of the NEPA of 1969 differently. The DOE process requires holding public hearings and reviews and the NRC process makes the documentation available to the public but does not hold hearings.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.13(a)	Pathways analyzed in demonstrating protection of the general population from releases of radioactivity must include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals.	DOE Order 5820.2A, Chapter III 3a(2)	Ensure that external exposure to waste and concentrations of radioactive material that may be released into surface or groundwater, soil, plants and animals results in an effective dose equivalent (EDE) that does not exceed 25 mrem/yr to any member of public.	Both citations are intended to identify the need to analyze radionuclide transport pathways.
Design	10 CFR 61.13(a)	The analyses must clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes.	DOE Order 5820.2A, Chapter III 3f(2)	Waste treatment techniques such as incineration, shredding, and compaction to reduce volume and provide more stable waste forms shall be implemented as necessary to meet performance requirements.	Both requirements acknowledge the need to consider both natural site confinement characteristics and also engineered barriers.
Design	10 CFR 61.13(a)	The analyses must clearly demonstrate that there is reasonable assurance that the exposure to humans from the release of radioactivity will not exceed the limits set forth in 10 CFR 61.41.	DOE Order 5820.2A, Chapter III 3a(2)	Assure that external exposure to the wastes and concentrations of radioactive material which may be released into surface water, ground water, soil, plants and animals result in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment at as low as reasonably achievable (ALARA).	Both NRC and DOE use 25 mrem/yr as the all-pathways dose limit, but in different dose systems. Thus, the actual level of protection is different.
Design	10 CFR 61.13(b)	Analyses of the protection of individuals from inadvertent intrusion must include demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.	DOE Order 5820.2A, Chapter III 3a(3)	LLW ... shall be managed to (3) Assure that the committed EDEs received by individuals who inadvertently may intrude into the facility after the loss of active institutional control shall not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure	Unlike the 10 CFR requirement, the DOE establishes a maximum dose that can be received by an inadvertent intruder. The theoretical dose to the intruder is calculated by site-specific PAs.
Design	10 CFR 61.13(c)	Analyses of the protection of individuals during operations must include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste.	DOE Order 5480.23 Paragraph 6.	It is the policy of the Dept. that nuclear facilities and operations be analyzed to identify all hazards and potential accidents associated with the facility and ...to establish designs and operational means to mitigate these hazards and potential accidents.	The DOE SAR process assesses all types of hazards and accidents, including operator radiation exposures.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.13(c)	The analyses of doses to individuals during operations must provide reasonable assurance that exposures will be controlled to meet the requirements of 10 CFR 20.1201.	10 CFR 835.202	The assessed dose from exposure of occupational workers to radiation shall not exceed the values summarized in Figure 1.	There are no differences in the permissible doses between 10 CFR 20 and 10 CFR 835.
Design	10 CFR 61.13(d)	Analyses of the long-term stability of the disposal site and the need for ongoing active maintenance after closure must be based upon analyses of active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill...	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	Both requirements mandate analysis to determine site stability performance and associated maintenance requirements. The DOE performance assessment will address the long-term performance of the facility.
Design	10 CFR 61.13(d)	The analyses must provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The closure plan will address required facility maintenance after closure.
Design	10 CFR 61.16	The Commission may also request information on (a) physical security measures, (b) safety information concerning criticality. This information is required for facilities receiving special nuclear material in quantities subject to 10 CFR 70.24 and 10 CFR 73.	DOE Order 6430.1A Sections 1300-10 and 1324-3	Section 1300-10 addresses design requirements for physical protection, material safeguards, and storage of special nuclear materials. Section 1324-3 addresses design requirements for criticality control.	The DOE 6430.1A, "General Design Criteria" establishes specific requirements for these topics. They are also required topics of the facility SAR governed by DOE Order 5480.23.
Licensing Requirements	10 CFR 61.23	A license for the receipt, possession, and disposal of waste ... will be issued by the Commission upon finding ... not be inimical to the common defense and security ... and health and safety of the public, and that standards of 10 CFR 61.23 are met.	Grumbly/ O'Toole Interim Policy Letter	Headquarters elements review and approve LLW disposal facilities PAs, and issue disposal authorization statements that set forth requirements important for assuring compliance with LLW disposal facility performance objectives.	DOE-HQ approval of the PA and issuance of the disposal authorization statement denotes that the disposal facility performance is deemed acceptable.
			DOE Order 5480.31, 1.	This order, entitled "Startup and Restart of Nuclear Facilities" has the stated purpose to establish the actions to be taken and to assign the responsibilities and authorities necessary for authorizing the startup or restart of DOE nuclear facilities.	The review and approval authorities to allow facility start-up activities are established by DOE Order 5480.31, based on potential hazard category of the facility.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Operations	10 CFR 61.24(g)	No radioactive waste may be disposed of until the Commission has inspected the land disposal facility and has found it to be in conformance with the description, design, and construction described in the application for a license.	DOE Order 5480.31 9.a(4)(a)	For initial startups of new hazard category 1 and 2 nuclear facilities, the Sec. of Energy, or designee, has startup authority. For initial startup of new hazard category 3 nuclear facilities, the Secretarial Officer, or designee, has startup authority.	Both the NRC and DOE have systems established to ensure that all design and operational aspects of the disposal facility are in order before waste receipt operations begin.
Operations	10 CFR 61.25	Except as provided for in specific license conditions, the licensee shall not make changes in the land disposal facility or procedures described in the license application. The license will include conditions restricting subsequent changes to the facility and the procedures authorized which are important to public health and safety.	DOE Order 5480.21 Section 10.b	A safety evaluation shall be performed when any of the following are not described in the existing safety analyses: (1) Temporary or permanent changes in the facility, (2) Temporary or permanent changes in the procedures, (3) Tests or experiments.	The DOE has defined an Unreviewed Safety Question process and if it is found that the above actions are not covered by the existing safety analyses (which include the performance assessment and SAR), the action must be reviewed and approved at the same approval level as the safety analyses.
Operations	10 CFR 61.25(a)	These license restrictions will fall into three categories of descending importance to public health and safety as follows: (1) those features and procedures which may not be changed ... [review and approval requirements of the 3 categories given in text].	DOE Orders 5480.21 and 5480.22	It is the policy of the Department that facilities operate within PSO-approved TSRs which prescribe the bounds for safe operations of these facilities in order to protect the health and safety of the public and reduce risk to workers.	The DOE Unreviewed Safety Question (USQ) process (established in DOE Order 5480.21) does not establish categories for approval, but operations may not proceed until the USQ is resolved and the solution approved at the same level of authority as the applicable safety analyses.
Operations	10 CFR 61.26(a)	An application for amendment of a license must be filed in accordance with 10 CFR 61.20 and shall fully describe the changes desired.	DOE Order 5480.21 Section 10.b	A safety evaluation shall be performed when any of the following are not described in the existing safety analyses: (1) Temporary or permanent changes in the facility, (2) Temporary or permanent changes in the procedures, (3) Tests or experiments.	The DOE system requires contractors to go through the formal Unreviewed Safety Question process to make changes to the safety envelope established by the SAR, PA, and the TSRs.
Closure	10 CFR 61.28(a)	Prior to final closure of the disposal site, or as otherwise directed by the Commission, the applicant shall submit an application to amend the license for closure.	DOE Order 5820.2A, Chapter III 3j(5)	Closure plans for new and existing operating LLW disposal facilities shall be reviewed and approved by the appropriate field organization.	The DOE contractor is responsible to obtain an approved closure plan for site closure.
Closure	10 CFR 61.28(a)	This closure application must include a final revision and specific details of the disposal site closure plan included as part of the license application submitted under 10 CFR 61.12(g) that includes the following: (1) Any additional geologic, ...	DOE Order 5820.2A, Chapter III 3j(5)	Closure plans for new and existing operating LLW disposal facilities shall be reviewed and approved by the appropriate field organization.	The DOE closure plan is the equivalent of the closure information in the license application.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Closure	10 CFR 61.28(b)	An environmental report or a supplement to an environmental report prepared in accordance with subpart A of 10 CFR 51 must accompany the application.	10 CFR 1021.3 14	DOE shall prepare a supplemental Environmental Impact Statement (EIS) if there are substantial changes to the proposal or significant new circumstances or information relevant to environmental concerns, as discussed in 40 CFR 1502.9(c)(2).	DOE is required to supplement the EIS governing its closure operation, if significant new circumstances or information is known at the time of the proposed closure operation.
Closure	10 CFR 61.28(c)	Upon review and consideration of an application to amend the license for closure submitted ..., the Commission shall issue an amendment authorizing closure if there is reasonable assurance that the long-term performance objectives will be met.	DOE Order 5480.23, Guidance Section 3a(1)	SARs provide the bases for approval of new facilities and operations, major modifications, and eventual decommissioning.	Since the closure activity is a major DOE operational activity, it will be covered by an approved SAR and the required closure plan. The approval of the SAR and final closure plan will be the DOE authorization for closure.
Closure	10 CFR 61.29	Following completion of closure authorized in 10 CFR 61.28, the licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the license is transferred by the Commission in accordance with 10 CFR 61.30.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	License transfer is not applicable for DOE facilities but the closure plan will ensure that post closure monitoring and maintenance is performed until it is technically justified to discontinue these functions.
Closure	10 CFR 61.29	Responsibility for the disposal site must be maintained by the licensee for 5 yr. A shorter or longer time period for post-closure observation and maintenance may be established and approved as part of the site closure plan based on site-specific conditions.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	License transfer is not applicable for DOE facilities but post closure monitoring and maintenance will be performed until it is technically justified to discontinue these functions.
Closure	10 CFR 61.30	Following closure and the period of post-closure observation and maintenance... The license shall be transferred when the Commission finds: (1) ..., (5) That the Fed. and State government agency which will assume responsibility for institutional control ...	N/A	N/A	Since the DOE is the owner for both the operational and the post-closure period, there is no equivalent to license transfer.
Closure	10 CFR 61.31(a)	Following any period of institutional control needed to meet the requirements found necessary under 61.23, the licensee may apply for an amendment to terminate the license.	N/A	N/A	Since the DOE is the owner for both the operation and the post-closure period there is no equivalent to license termination.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Closure	10 CFR 61.31(b)	A license is terminated when (1) institutional control requirements have been met, (2)...any additional requirements resulting from new information developed during the institutional control period have been met and markers have been installed.	N/A	N/A	Since the DOE is the owner for both operation and the post-closure period there is no equivalent to license termination.
Design	10 CFR 61.40	Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in 61.41 through 61.44.	DOE Order 5820.2A, Chapter III 3b(1)	Field organizations with disposal sites shall prepare and maintain a site-specific radiological performance assessment for the disposal of waste for the purpose of demonstrating compliance with the performance objectives stated in para. 3a.	Both citations require that radiation exposures to the public meet similar criteria.
Design	10 CFR 61.41	Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, ...	DOE Order 5820.2A, Chapter III 3a(2)	Ensure that external exposure to waste and concentrations of radioactive material which may be released into surface or ground water, soil, plants and animals results in an EDE that does not exceed 25 mrem/yr to any member of the public.	The limit from in 10 CFR 61.41 is the same as the DOE stated limit with the exception that 10 CFR 61.41 allows 75 mrem to the thyroid. The DOE limit is more conservative. Thyroid exposure due to iodine should not be significant for waste emissions.
Design	10 CFR 61.41	Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.	DOE Order 5820.2A, Chapter III 3a(2)	Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment ALARA.	It is general DOE policy to always perform the ALARA process in design and operational activities.
Design	10 CFR 61.42	Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contracting the waste at any time after active institutional controls are removed.	DOE Order 5820.2A, Chapter III 3a(3)	DOE LLW ... shall be managed to (3) ensure that the committed EDEs received by individuals who inadvertently may intrude into the facility after the loss of active institutional control shall not exceed 100 mrem/yr for continuous exposure.	The DOE performance assessment must address the protection of the inadvertent intruder and analyze how the performance objective for this event will be met.
Operations	10 CFR 61.43	Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in part 20 of this chapter, except for releases in effluents from the land disposal facility which shall be governed by 61.41.	DOE Order 5480.11 and 10 CFR 835	DOE Order 5480.11 and the recently codified 10 CFR 835 establish radiation protection requirements for DOE occupational workers. The equivalent for the 10 CFR 61.41 requirement is found under a discussion of that requirement.	DOE has equivalent requirements to the those of the NRC for worker protection and effluent releases.
Operations	10 CFR 61.43	Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.	DOE Orders 5400.5 Chapter I.4	Accordingly, this Order adopts the ALARA process in planning and carrying out all DOE activities.	It is general DOE policy to always perform the ALARA process in design and operational activities.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.44	The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The NRC places more emphasis on minimizing the need for maintenance during the institutional control period than the DOE does.
Siting	10 CFR 61.50(a)(2)	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored.	DOE Order 5820.2A, Chapter III 3i(8)(b)	Disposal units shall be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with the NEPA process.	Both requirements emphasize the need to model and technically analyze the disposal site.
Siting	10 CFR 61.50(a)(3)	Within the region or state where the facility is located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives.	DOE Order 5820.2A, Chapter III 3i(7)(e)	Site selection criteria shall address the impact on current and projected populations, land use resource development plans and nearby facilities, accessibility to transportation routes and utilities, and the location of waste generation.	Both citations have the same intent.
Siting	10 CFR 61.50(a)(4)	Areas must be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of subpart C of this part.	DOE Order 5820.2A, Chapter III 3i(7)(e)	Site selection criteria shall address the impact on current and projected populations, land use resource development plans and nearby facilities, accessibility to transportation routes and utilities, and the location of waste generation.	Both requirements require the consideration of the site for future industrial use.
Siting	10 CFR 61.50(a)(5)	The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-yr flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988.	DOE Order 6430.1A Section 0285-2.2.2	The following environmentally sensitive areas shall be avoided or receive lowest siting priority for TSD of ...and radioactive solid waste: (a) Wetlands, (b) Areas within the 500-yr floodplain, (c) Permafrost areas, (d) critical habitats of endangered species, (e) ...	The DOE Order 6430.1A, "General Design Criteria," identifies environmental sensitive areas like the NRC requirement.
Siting	10 CFR 61.50(a)(6)	Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.	DOE Order 6430.1A Section 0285-2.1	The following conditions and requirements shall be considered during the selection of solid waste TSD sites: (a) Existing groundwater and surface water conditions, (b) Soils and geologic and topographic features, ...	Both requirements recognize the need to consider surface water conditions.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Siting	10 CFR 61.50(a)(7)	The disposal site must provide sufficient depth to the water table that ground water intrusion, perennial or otherwise, into the waste will not occur. The Commission will consider an exception to this requirement ... if it can be conclusively shown ...	DOE Order 6430.1A Section 0285-3.2.3	The following shall be considered to determine potential impacts on groundwater resources: ... (b) Depth to groundwater and ... , (c) Potential interactions of the solid waste system and its hydrogeology with areal, groundwater, and surface water resources ...	Both citations have the same intent.
Siting	10 CFR 61.50(a)(7)	In no case will waste disposal be permitted in the zone of fluctuation of the water table.	DOE Order 6430.1A Section 0285-3.2.3	The following shall be considered to determine potential impacts on groundwater resources: ... (b) Depth to groundwater and ... , (c) Potential interactions of the solid waste system and its hydrogeology with areal, groundwater, and surface water resources ...	Both citations have the same intent.
Siting	10 CFR 61.50(a)(8)	The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site.	DOE Order 6430.1A Section 0285-3.2.3	The following shall be considered to determine potential impacts on groundwater resources: ... (b) Depth to groundwater and ... , (c) Potential interactions of the solid waste system and its hydrogeology with areal, groundwater, and surface water resources ...	Both citations have the same intent.
Siting	10 CFR 61.50(a)(9)	Areas must be avoided where tectonic processes such as faulting, folding, ... may occur with such frequency and extent to significantly affect the ability of the site to meet the performance objectives or may preclude defensible modeling and prediction...	DOE Order 6430.1A Section 0285-2.2.3	When potential sites are screened for location of new solid waste TSD facilities, seismic zones and karst (limestone formation) terrain shall be avoided unless site-specific evaluations demonstrate minimum potential for contamination of surface water, ...	The intent of the citations is the same.
Siting	10 CFR 61.50(a)(10)	Areas must be avoided where surface geologic processes such as mass wasting, erosion ... may occur with such frequency and extent to significantly affect the ability of the site to meet the performance objectives or may preclude defensible modeling and...	DOE Order 5820.2A, Chapter III 3i(7)(d)	The potential for natural hazards such as floods, erosion, tornadoes, earthquakes, and volcanoes shall be considered in site selection.	The citations have the same intent.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Siting	10 CFR 61.50(a)(11)	The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of subpart C of this part or significantly mask the environmental monitoring program.	DOE Order 6430.1A Section 0285-2.2.8	Sites that would adversely affect operation of other facilities should be avoided.	Both criteria site the need to address interactions between adjacent facilities in site selection.
Design	10 CFR 61.51(a)(1)	Site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The NRC places more emphasis on minimizing the need for maintenance during the institutional control period than the DOE does.
Design	10 CFR 61.51(a)(2)	The disposal site design and operation must be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives of subpart C of this part will be met.	DOE Order 5820.2A, Chapter III 3a	DOE LLW shall be managed on the schedule developed in the Implementation Plan to accomplish the performance objectives stated in DOE Order 5820.2A, Chapter III, Section 3a.	Both statements establish the criteria that the facility design address long-term performance objectives.
Design	10 CFR 61.51(a)(3)	The disposal site must be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to ensure that the performance objectives of subpart C of this part will be met.	DOE Order 5820.2A, Chapter III 3i(8)(b)	Disposal units shall be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with the NEPA process.	Both statements have the same intent.
Design	10 CFR 61.51(a)(4)	Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.	DOE Order 6430.1A Section 1324-5.3	Means shall be provided to minimize contact of emplaced low-level waste with water. Active water control measures shall not be required following permanent closure. Typical requirements for water control are: (a) placing a layer of highly permeable ...	DOE Order 6430.1A, "General Design Criteria," gives detailed design guidance for means of water control at a disposal facility.
Design	10 CFR 61.51(a)(5)	Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.	DOE Order 6430.1A Section 0285-2.1	The following conditions and requirements shall be considered during the selection of solid waste TSD sites: (a) existing groundwater and surface water conditions, (b) soils and geologic and topographic features, ...	Both citations address the control of ground water away from the disposal facility.
Design	10 CFR 61.51(a)(5)	Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.	DOE Order 5820.2A, Chapter III 3i(7)(c)	The disposal site shall have hydrogeologic characteristics which, in conjunction with the planned waste confinement technology, will protect the groundwater resource.	Both citations address the control of ground water away from the disposal facility.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.51(a)(6)	The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.	DOE Order 6430.1A Section 1324-5.3	Means shall be provided to minimize contact of emplaced low-level waste with water. Active water control measures shall not be required following permanent closure. Typical requirements for water control are: (a) placing a layer of highly permeable ...	DOE Order 6430.1A, "General Design Criteria," gives detailed design guidance for means of water control at a disposal facility.
Design	10 CFR 61.52(a)(1)	Class A wastes must be segregated from other wastes by placing in disposal units which are sufficiently separated from disposal units for other wastes classes so that interaction between Class A wastes and other wastes will not result in failure to meet performance objectives in subpart C. The segregation is not necessary for Class A wastes if they meet the stability requirements in 61.56(b) of this part.	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	DOE does not have preset classification categories for waste as required by the NRC. Unlike the NRC, DOE determines allowable disposal practices for different types of waste on a case-by-case basis, as determined by the performance assessment. The NRC prescribes waste form and disposal requirements without considering site-specific details.
Design	10 CFR 61.52(a)(2)	Class C wastes must be disposed of so that the top of the waste is a minimum of 5 m below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 yr.	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	DOE determines allowable disposal practices for different types of waste on a case-by-case basis, as determined by the performance assessment. DOE Order 5820.2A DOE Order 5820.2A, Chapter III.3a(3) states the allowable dose scenario.
Design	10 CFR 61.52(a)(3)	All wastes shall be disposed of in accordance with the requirements of paragraphs (a)(4) through (11) of this section.	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	DOE determines allowable disposal practices for different types of waste on a case-by-case basis, as determined by the performance assessment.
Design	10 CFR 61.52(a)(4)	Wastes must be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled.	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	DOE addresses package integrity requirements as part of the performance assessment. Issues such as initial strength and expected life of the package must be addressed in the analysis.
Design	10 CFR 61.52(a)(5)	Void spaces between waste packages must be filled with earth or other material to reduce future subsidence within the fill.	DOE Order 5820.2A, Chapter III 3i(9)(d)	Waste placement into disposal units should minimize voids between containers.	Both citations are concerned with minimizing voids between waste packages.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Closure	10 CFR 61.52(a)(6)	Waste must be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with provisions of 10 CFR 20.1301 and .1302 at the time the license is transferred.	DOE Order 5820.2A, Chapter III 3j(2)	During closure and post closure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines.	Both citations are concerned with limiting the potential radiation exposures at the surface of the facility upon closure.
Design	10 CFR 61.52(a)(7)	The boundaries and locations of each disposal unit must be accurately located and mapped by means of a land survey.	DOE Order 5820.2A, Chapter III 3i(9)(b)	Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	Both citations address the need to relocate the site boundaries.
Design	10 CFR 61.52(a)(7)	Near surface disposal units must be marked in such a way that the boundaries of each unit can be easily defined.	DOE Order 5820.2A, Chapter III 3i(9)(b)	Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	The citations both address marking the site boundaries.
Design	10 CFR 61.52(a)(7)	Three permanent survey marker control points, referenced to U.S. Geological Survey (USGS) or National Geodetic Survey (NGS) survey control stations, must provide horizontal and vertical controls as checked against USGS or NGS record files.	DOE Order 5820.2A, Chapter III 3i(9)(b)	Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	The NRC requirement more specifically addresses the marker requirements for the site. This is a design detail which should inherently be considered in erecting permanent site markers.
Design	10 CFR 61.52(a)(8)	A buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in 61.53(d)...	DOE Order 5820.2A, Chapter III 3k(4)	The monitoring program shall be capable of detecting changing trends in the performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives.	Although DOE does not specifically require a buffer zone, it is normal in the design of a monitoring plan which must detect trends in time to prevent exceeding performance dose objective to a surrounding public.
Closure	10 CFR 61.52(a)(9)	Closure and stabilization measures as set forth in the approved site closure plan must be carried out as each disposal unit (e.g., each trench) is filled and covered.	DOE Order 5820.2A, Chapter III 3i(9)(a)	Field organizations shall develop and implement operating procedures for LLW disposal facilities that protect the environment, health and safety of the public, and facility personnel; ensure the security of the facility; minimize the need for long-term control; and meet ...	The closure plan, which is completed prior to first waste receipt, establishes the closure and stabilization measures and schedule for DOE sites.
Design	10 CFR 61.52(a)(10)	Active waste disposal operations must not have an adverse effect on completed closure and stabilization measures.	DOE Order 5820.2A, Chapter III 3i(9)(e)	Operations are to be conducted so that active waste disposal operations will not have an adverse effect on filled disposal units.	The intent of the two statements is the same.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Waste Form	10 CFR 61.52(a)(11)	Only wastes containing or contaminated with radioactive materials shall be disposed of at the disposal site.	DOE Order 5820.2A, Chapter III 3i(6)	Wastes containing amounts of radionuclides below regulatory concern, as defined by Federal regulations, may be disposed of without regard to radioactivity content.	The NRC and DOE requirements are consistent with standard waste minimization requirements to minimize waste volumes.
Operations	10 CFR 61.53(a)	At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics.	DOE Order 5400.1, Ch. IV.3	An environmental monitoring study shall be conducted prior to start up of a new site, facility, or process, which has the potential for significant adverse environmental impact. ... The study shall serve to: characterize existing physical chemical, and ...	The intent of these two requirements is the same.
Operations	10 CFR 61.53(a)	The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, data must cover a 12-month period.	DOE Order 5400.1, Ch. IV.3	The preoperational study should begin not less than 1 yr, and preferably 2 yr before start up to evaluate seasonal changes. The study shall serve to characterize existing physical, chemical, and biological conditions that could be affected; ...	The intent of both of these requirements is to identify site characteristics prior to beginning operations to form a baseline.
Operations	10 CFR 61.53(b)	The licensee must have plans for taking corrective measures if migration of radionuclides would indicate that the performance objectives of subpart C may not be met.	DOE Order 5820.2A, Chapter III 3j(3)	Corrective measures shall be applied to new disposal sites or individual disposal units if conditions occur or are forecasted that could jeopardize attainment of the performance objectives of this Order.	Unlike the NRC, no written requirement was found for a DOE corrective action plan in the event that the monitoring plan shows releases have occurred which will exceed the performance objectives.
Operations	10 CFR 61.53(c)	During the land disposal facility site construction and operation, the licensee shall maintain a monitoring program.	DOE Order 5400.1 Chapter IV	This Order requires a site monitoring program with a plan that identifies monitoring requirements for the pre-operational, operational, and post-closure phases of the disposal facility operation.	The two citations both dictate monitoring during the various phases of facility operation.
Operations	10 CFR 61.53(c)	Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need...	DOE Order 5820.2A, Chapter III 3m(1)	Each field organization shall develop and maintain a record keeping system that records: (a) historical record of waste generated, treated, stored, shipped, disposed of, or both, at the facilities under its cognizance. The data maintained shall include all data necessary to show that the waste was properly classified, treated, stored, shipped, and/or disposed of.	Although the DOE citation does not specifically include monitoring during the construction phase of the operation, it seems to be included in the facility monitoring program.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Design	10 CFR 61.53(c)	The monitoring system (used during site construction and operation) must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.	DOE Order 5820.2A, Chapter III 3k(4)	The monitoring program shall be capable of detecting changing trends in the performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives.	These citations have the same intent.
Operations	10 CFR 61.53(d)	After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site.	DOE Order 5400.1 Chapter IV	This Order requires a site monitoring program with a plan that identifies monitoring requirements for the pre-operational, operational, and post-closure phases of the disposal facility operation.	The intent of these citations is the same.
Design	10 CFR 61.53(d)	The monitoring system (used for post operational surveillance) must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.	DOE Order 5820.2A, Chapter III 3k(4)	The monitoring program shall be capable of detecting changing trends in the performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives.	The intent of the two statements is the same.
Design	10 CFR 61.54	The Commission may, upon request or on its own initiative, authorize provisions other than those set forth in 61.51 through 61.53 for the segregation and disposal of waste and for the design and operation of a land disposal facility on a specific basis, if...	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	This and statements like it, which allow exceptions to the rules, make the requirements of 10 CFR 61 changeable with technical justification. DOE relies on the performance assessment to establish requirements based on technical justification.
Waste Form	10 CFR 61.55(a)(1)	First, consideration must be given to the concentration of long-lived radionuclides whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications.
Waste Form	10 CFR 61.55(a)(2)(i)	Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in 61.56(a).	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Waste Form	10 CFR 61.55(a)(2)(i)	If Class A waste also meets the stability requirements set forth in 61.56(b), it is not necessary to segregate the waste for disposal.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications and disposal criteria.
Waste Form	10 CFR 61.55(a)(2)(ii)	Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in 61.56.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications.
Waste Form	10 CFR 61.55(a)(2)(iii)	Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications, waste form, and disposal criteria.
Waste Form	10 CFR 61.55(a)(2)(iii)	The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in 61.56.	DOE Order 5820.2A, Chapter III 3i(2)	In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications and waste form criteria.
Waste Form	10 CFR 61.55(a)(2)(iv)	Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste.	DOE Order 5820.2A, Chapter III 3i(4)	Disposition of waste designated as GTCC, as defined in 10 CFR 61.55, must be handled as special cases.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications and disposal criteria.
Waste Form	10 CFR 61.55(a)(2)(iv)	In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in part 60 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved	DOE Order 5820.2A, Chapter III 3i(4)	Disposition of waste designated as GTCC, as defined in 10 CFR 61.55, must be handled as special cases.	DOE has chosen to rely on the performance assessment results as a basis to determine the waste acceptance criteria of the disposal facility, rather than having predetermined low-level waste classifications and disposal criteria.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Waste Form	10 CFR 61.55(a)(8)	The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate inferred concentration of one radionuclide to another that is measured, or indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed in nCi/g.	DOE Order 5820.2A, Chapter III 3d(3)	The concentration may be determined by direct methods or by indirect methods such as using of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is ...	Both requirements allow the use of indirect methods such as the use of scaling factors. DOE 5820.2A does not include a statement on concentration averaging but guidance on concentration averaging is provided in DOE/LLW-75T.
Waste Form	10 CFR 61.56(a)(1)	Waste must not be packaged for disposal in cardboard or fiberboard boxes.	DOE Order 5820.2A, Chapter III 3i(5)(a)	(a) Waste must not be packaged for disposal in cardboard or fiberboard boxes, unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space.	DOE has chosen to specify waste container requirements in the waste acceptance criteria based on technical considerations of the wasteform, handling processes, and disposal considerations.
Waste Form	10 CFR 61.56(a)(2)	Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of liquid.	DOE Order 5820.2A, Chapter III 3i(5)(b)	(b) Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as reasonably achievable, but in no case, shall the liquid exceed 1% of the volume of the waste when ...	Both citations are concerned with solidifying free liquid. The NRC is more prescriptive.
Waste Form	10 CFR 61.56(a)(3)	Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.	DOE Order 5820.2A, Chapter III 3i(5)(b)	(b) Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as reasonably achievable, but in no case, shall the liquid exceed 1% of the volume of the waste when ...	The DOE requirement also addresses free liquid requirements for a stabilized wasteform.
Waste Form	10 CFR 61.56(a)(4)	Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.	DOE Order 5820.2A, Chapter III 3i(5)(c)	(c) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures or of explosive reaction with water.	The requirements are the same.
Waste Form	10 CFR 61.56(a)(5)	Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gases packaged in accordance with (a)(7).	DOE Order 5820.2A, Chapter III 3i(5)(d)	(d) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged as identified in para. 3i(5)(e).	The requirements are the same.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Waste Form	10 CFR 61.56(a)(6)	Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.	DOE Order 5820.2A, Chapter III 3i(5)(f)	(f) Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.	The requirements are the same.
Waste Form	10 CFR 61.56(a)(7)	Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total activity must not exceed 100 Ci per container.	DOE Order 5820.2A, Chapter III 3i(5)(e)	(e) Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C.	The criteria are the same except the NRC specifies the maximum number of curies per container. The DOE leaves waste acceptance criteria to be decided by a site-specific performance assessment.
Waste Form	10 CFR 61.56(a)(8)	Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.	DOE Order 5820.2A, Chapter III 3e(5)(f)	The waste acceptance criteria for storage, treatment, or disposal facilities shall address the following issues: (f) Chemical and structural stability of waste packages, radiation effects, microbial activity, chemical reactions, and moisture.	The intent of the two statements is to place limiting criteria on these types of waste. Neither is very prescriptive. The DOE relies on the site-specific analysis to create the limitations placed on these types of waste.
Waste Form	10 CFR 61.56(b)(1)	Waste must have structural stability. A structurally stable waste will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, ...	DOE Order 5820.2A, Chapter III 3e(5)(f)	The waste acceptance criteria for storage, treatment, or disposal facilities shall address the following issues: (f) Chemical and structural stability of waste packages, radiation effects, microbial activity, chemical reactions, and moisture.	The DOE establishes waste form requirements based on site-specific performance assessment results and reflects those requirements in the facility waste acceptance criteria. Unlike the NRC, DOE does not impose mandatory waste stabilization requirements.
Waste Form	10 CFR 61.56(b)(2)	Not withstanding the provisions in 61.56(a)(2) and(3), liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing and noncorrosive liquid as is reasonably achievable.	DOE Order 5820.2A, Chapter III 3i(5)(b)	(b) Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as reasonably achievable, but in no case, shall the liquid exceed 1% of the volume of the waste when ...	The statements are similar, but the NRC restricts corrosive liquids, although it is not prescriptive in defining what a corrosive liquid is.
Waste Form	10 CFR 61.56(b)(2)	In no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.	DOE Order 5820.2A, Chapter III 3i(5)(b)	(b) Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as reasonably achievable, but in no case, shall the liquid exceed 1% of the volume of the waste when ...	The statements are the same.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Waste Form	10 CFR 61.56(b)(3)	Void spaces within the waste and between the waste and its package must be reduced to the extent practicable.	DOE Order 5820.2A, Chapter III 3i(9)(d)	Waste placement into disposal units should minimize voids between containers.	The DOE criteria does not address minimizing the void space within the waste. This an issue dealing with waste form stability and is left to DOE site-specific waste acceptance criteria, based on performance assessment determination of needs.
Operations	10 CFR 61.57	Each package of waste must be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with 61.55.	N/A	N/A	DOE has chosen to address its waste on a site-specific basis rather than having pre-determined LLW classifications. Therefore, it does not have these designations. However, some DOE facilities use similar LLW classification systems.
Waste Form	10 CFR 61.58	The commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a specific basis, if, after evaluation, of ..., it finds reasonable assurance of compliance with performance objective.	DOE Order 5820.2A, Chapter III 3i(1)	LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in para. 3a, consistent with the disposal site radiological performance assessment in para. 3b.	The DOE allows technical criteria developed during the performance assessment to be implemented in waste acceptance criteria which is adopted into the safety envelope of the operating facility. The NRC allows this on an exception basis.
Closure	10 CFR 61.59(b)	The land owner or custodial agency shall carry out an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator.	DOE Order 5820.2A, Chapter III 3i(9)(a)	Field organizations. shall develop and implement operating procedures for LLW disposal facilities that protect the environment, health and safety of the public, and facility personnel; ensure the security of the facility; minimize the need for long-term control; and meet ...	DOE requires the closure plan to establish security requirements for the institutional control period.
Closure	10 CFR 61.59(b)	The institutional control program must also include, but not be limited to, carrying out an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other requirements as determined by the Commission.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The DOE requires a minimum of 100 yr of monitoring and maintenance of the disposal site. Further requirements for institutional control will be established in the closure plan which is completed prior to waste receipt and continually maintained.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Closure	10 CFR 61.59(b)	The period of institutional controls will be determined by the Commission, but institutional controls may not be relied upon for more than 100 yr following transfer of control of the disposal site to the owner.	DOE Order 5820.2A, Chapter III 3j(6)	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	The DOE requires a minimum of 100 yr of monitoring and maintenance of the disposal site. Further requirements for institutional control will be established in the closure plan which is completed prior to waste receipt and continually maintained.
Operations	10 CFR 61.80(a)	Each licensee shall maintain any records and make any reports in connection with the licensed activities as may be required by the conditions of the license or by the rules, regulations, and orders of the Commission.	DOE Order 5820.2A, Chapter III 3m(1)	Each field organization shall develop and maintain a record keeping system that records: (a) historical record of waste generated, treated, stored, shipped, disposed of, or both, at the facilities under its cognizance.	The specifications for the DOE records is less defined in DOE 5820.2A than in 10 CFR 61. Records requirements are found in several other DOE orders.
Operations	10 CFR 61.80(b)	Records which are required by the regulations in this part or by license conditions must be maintained for a period specified by the appropriate regulations in this chapter or by license condition.	DOE Order 5820.2A, Chapter III 3m(2)	Waste manifests shall be kept as permanent records. The following data will be included (a) waste physical and chemical characteristics; (b) quantity of each radionuclide; (c) weight of the waste; (d) volume of the waste; (e) other data for compliance with Waste Acceptance Criteria (WAC)...	Required records are not very well defined in the 5820.2A Order and it is not made clear what document specifies required records as done by NRC in license requirements.
Operations	10 CFR 61.80(b)	Records which are required by the regulations in this part or by license conditions must be maintained for a period specified by the appropriate regulations in this chapter or by license condition.	DOE Order 1324.2B, Section 1.	To establish the DOE records management policy and program for managing records.	DOE Order 1324.5B addresses records management, but does not specifically address the records management for a low-level waste disposal facility.
Operations	10 CFR 61.80(b)	If a retention period is not otherwise specified, these records must be maintained and transferred to the officials specified in para. (e) of this section as a condition of license termination unless the Commission otherwise authorizes their disposition.	N/A	N/A	Since DOE is both the owner and operator, there is no transfer of records.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Operations	10 CFR 61.80(c)	Records which must be maintained pursuant to this part may be the original or a reproduced copy or a microform if this reproduced copy or microform is capable producing copy that is clear and legible at the end of the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, specifications, must include all pertinent information such as stamps, initials, and signatures.	DOE Order 5820.2A, Chapter III 3m(1)	The data maintained in the system shall be based on data recorded on waste manifests.	The DOE requirements for disposal records does not identify any criteria for acceptable records form. This may lead to very different and non-uniform records keeping across the DOE complex.
Operations	10 CFR 61.80(c)	The licensee shall maintain adequate safeguards against tampering with and loss of records.	DOE Order 5820.2A, Chapter III, 3m	No information on safeguards for records and reports is in Chapter III of DOE 5820.2A.	The DOE requirements for disposal records does not identify any criteria for providing safeguards against tampering and loss of records.
Operations	10 CFR 61.80(e)	Notwithstanding para. (a)-(d) of this section, the licensee shall record the location and the quantity of radioactive wastes contained in the disposal site and transfer these records upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land ...	NA	NA	There is no transfer of records in the DOE system since they are both the owner and operator.
Operations	10 CFR 61.80(f)	The licensee shall record the date that the shipment is received at the disposal facility, the date of disposal of the waste, a traceable shipment manifest number, a description of any engineered barrier or structural overpack provided for disposal ...	DOE Order 5820.2A, Chapter III 3m(2)	Records shall be kept and accompany each waste package from generator through final disposal. The manifest shall contain data necessary to document the proper classification, and assist in determining proper treatment, storage, and disposal of the waste. Waste manifests shall be kept as permanent records. The following data will be included (a) waste physical and chemical characteristics; (b) quantity of each radionuclide; (c) weight of the waste; (d) volume of the waste; (e) other data for compliance with WAC...	The intent of the requirements to maintain needed records seems to be the same. The NRC requirements are more specific.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Operations	10 CFR 61.80(g)	Each licensee shall comply with the safeguards reporting requirements of 30.55, 40.64, 70.53, and 70.54 of this chapter if the quantities or activities of materials received or transferred exceed the limits of these sections.	Safeguards and Security Orders	DOE has specific Orders which address reporting requirements for accountable materials. These are DOE Order 5633.2A, "Control and Accountability of Nuclear Materials: Responsibilities and Authorities;" DOE Order 5633.4, "Nuclear Materials Transactions: Documentation and Reporting;" and DOE Order 5633.5, "Nuclear Materials Reporting and Data Submission Procedures."	DOE routinely keeps records for accountable nuclear materials.
Operations	10 CFR 61.80(i)(1)	Each licensee authorized to dispose of waste materials received from other persons, pursuant to this part, shall submit annual reports to the appropriate Commission regional office shown in Appendix D to 10 CFR 20, with copies to ...	DOE Order 5400.1, Chapter II, 4.c	All DOE facilities that conduct significant environmental protection programs shall prepare an Annual Site Environmental Report. Environmental reports covering the previous calendar year shall be prepared annually and distributed by June 1 to EH-1, appropriate PSOs, ...	Both agencies require an annual report centered around environmental monitoring results.
Operations	10 CFR 61.80(i)(2)	These annual reports shall include (i) specification of the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in airborne effluents during the preceding year, (ii) results of the environmental monitoring program, (iii) a summary of licensee disposal unit survey and maintenance activities, (iv) a summary, by waste class, of activities and quantities of radionuclides disposed of, (v) any instances in which observed site characteristics were significantly different from those described in the application for a license, and (vi) any other information the commission may require.	DOE Order 5400.1, Attachment II-1	Content and format for the Annual Site Environmental Report is provided in Attachment II-1, Page II-5.	Both the DOE and NRC report require the results of the environmental monitoring activities. The NRC report requirements are written more specifically for a disposal facility, whereas the DOE requirements are written for any DOE activity requiring environmental monitoring.
Operations	10 CFR 61.80(i)(2)	If the quantities of radioactive materials released during the reporting period, monitoring results, or maintenance performed are significantly different from those expected in the materials previously reviewed as part of the licensing action, the report must cover this specifically.	DOE Order 5400.1 Chapter II.5(b)	Unplanned releases of radioactive materials in effluents, such as spills, leaks, etc., whether onsite or offsite, also shall be reported to the Information System Branch, on Form DOE F 5821.1. This is in addition to reporting requirement of DOE Order 5000.3A.	Both citations are intended to identify unusual environmental releases.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Operations	10 CFR 61.80(j)	Each licensee shall report in accordance with the requirements of 10 CFR 70.52 (Reports of accidental criticality or loss or theft or attempted theft of special nuclear material).	DOE Order 5000.3B, Attachment 1, J	Loss or apparent loss of one or more items for which the items total a Category III or greater quantity of special nuclear material is classified as an emergency or unusual occurrence which must be reported as required in DOE Order 5000.3B.	Both DOE and commercial facilities must report loss of special nuclear material and criticality events in a timely fashion.
Operations	10 CFR 61.80(k)	Any transfer of byproduct, source, and special nuclear materials by the licensee is subject to the requirements of 10 CFR 30.41, 40.51, and 70.42.	DOE Order 5633.3B, Chapter I.1.a	Special nuclear material shall not be received, processed, or stored at a facility until facility approval has been granted in accordance with requirements of DOE Order 5634.1B, Facility Approval, Security Surveys, and Nuclear Material Surveys.	Both citations place qualification requirements upon parties transferring nuclear material.
Operations	10 CFR 61.80(l)	In addition to other requirements of this section, the licensee shall store or have stored, manifest and other information pertaining to receipt and disposal of radioactive waste in an electronic recordkeeping system.	DOE Order 5820.2A, Chapter III, 3m	Each field organization shall develop and maintain a recordkeeping system that records the following: a historical record of waste generated, treated, stored, shipped, disposed of ... The data maintained shall include all data necessary to show that the waste was properly classified, treated, stored, shipped, and/or disposed of. --- Waste manifests shall be kept as permanent records.	The intent of these requirements appears to be the same.
Operations	10 CFR 61.81(a)	Each licensee shall perform, or permit the Commission to perform, any tests as the Commission deems appropriate or necessary for the administration of the regulations of this part, including tests of: (1) radioactive wastes and facilities used ...	DOE Order 5820.2A, Chapter III 3l	Consistent with DOE Order 5700.6B, the LLW operational and disposal practices shall be conducted in accordance with applicable requirements of ANSI/ASME NQA-1 and other appropriate national consensus standards.	This requirement points out the difference between the NRC and DOE systems for oversight. The NRC has oversight by an independent agency and the DOE utilizes contractor and DOE quality assurance programs to implement oversight.
Operations	10 CFR 61.82(a)	Each licensee shall afford to the Commission at all reasonable times opportunity to inspect radioactive waste not yet disposed of, and the premises, equipment, operations, and facilities in which radioactive wastes are received, possessed, handled, ...	DOE Order 5820.2A, Chapter III 3l	Consistent with DOE Order 5700.6B, the LLW operational and disposal practices shall be conducted in accordance with applicable requirements of ANSI/ASME NQA-1 and other appropriate national consensus standards.	This requirement points out the difference between the NRC and DOE systems for oversight. The NRC has oversight by an independent agency and the DOE utilizes contractor and DOE quality assurance programs to implement oversight.

Table B-1. (continued).

Topic	NRC ref	Commercial requirement	DOE ref	DOE requirement	Discussion
Operations	10 CFR 61.82(b)	Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by it pursuant to the regulations in this chapter.	DOE Order 5820.2A, Chapter III 3l	Consistent with DOE Order 5700.6B, the LLW operational and disposal practices shall be conducted in accordance with applicable requirements of ANSI/ASME NQA-1 and other appropriate national consensus standards.	This requirement points out the difference between the NRC and DOE systems for oversight. The NRC has oversight by an independent agency and the DOE utilizes contractor and DOE quality assurance programs to implement oversight.
Operations	10 CFR 61.83(a)	The Commission may obtain an injunction or other court order to prevent a violation of the provisions of (1) The Atomic Energy Act of 1954, as amended, (2) Title II of the Energy Reorganization Act of 1974, as amended, (3) A regulation or order issued ...	DOE Order 5000.3B, Section 6.	It is the policy of the Depart...that occurrences be consistently reported to ensure...management are kept fully and currently informed of all events... It is also the policy of the Dept. that there be a system for determining appropriate corrective action and ...	DOE has established an occurrence reporting system which required early notification to both DOE and contractor line management of occurrences and a documented root cause analysis to ensure that appropriate immediate and long-term action is taken.

Appendix C

Comparison of Non-DOE and DOE Waste Acceptance Criteria

Appendix C

Comparison of Non-DOE and DOE Waste Acceptance Criteria

A comparison of waste acceptance criteria for the existing Barnwell and Richland commercial disposal facilities and four DOE disposal facilities is shown in Table C-1. The intent of the comparison is to determine if DOE and commercial facilities are different for similar waste acceptance parameters. The comparison only serves as a brief comparison of a few selected areas.

To effect a comparison, reviewers had to establish parameters to be compared. Realizing that these parameters are arbitrary, reviewers elected to use the parameters from a previous work. Comparison parameters were taken from:

> Thomas A. Kerr, *Matrix and Cross-References For Current, Former, and Proposed/Suggested Low-Level Radioactive Waste Acceptance Criteria*, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, Lockheed Idaho Technologies Company, Revision 4, February 9, 1995.

The above document was established to compare waste acceptance criteria of existing, former, and proposed commercial disposal facilities and has been used by proposed commercial sites as an information source while preparing their waste acceptance criteria. The information, from the original work, for the Richland and Barnwell commercial facilities was kept for this comparison and four DOE facilities were chosen to add to the table for comparison to the two commercial facilities. The DOE facilities chosen represent two arid sites and two humid sites.

The following documents were used as sources for the waste acceptance criteria that appear in the matrix:

Nuclear Regulatory Commission	1.	Title 10 of the Code of Federal Regulations Part 61
	2.	Title 10 of the Code of Federal Regulations Part 20 Appendix F
	3.	*Technical Position on Waste Form*, Revision 1, January 1991 (Abbreviation Used in Matrix: BTP)
Barnwell, South Carolina	1.	South Carolina Department of Health and Environmental Control Radioactive Material License #097 Amendment 45 (Abbreviation Used in Matrix: SCL)
	2.	U.S. Nuclear Regulatory Commission License #12-13536-01 Amendment 24 (Abbreviation Used in Matrix: NRCL)
	3.	Barnwell Waste Management Facility Site Disposal Criteria (Chem-Nuclear Systems, Inc. Document # S20-AD-010 Revision 8) (Abbreviation Used in Matrix: BSC)

Richland, Washington	1.	State of Washington Radioactive Materials License #WN-I019-2 Amendment #18 (Abbreviation Used in Matrix: WAL)
	2.	U.S. Nuclear Regulatory Commission License #16-19204-01 Amendment 11 (Abbreviation Used in Matrix: NRCL)
	3.	State of Washington Administrative Code 246-249-080 (for NORM)
DOE Nevada Test Site (NTS)	1.	*Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements*, NVO-325, Revision 1, June 1992.
DOE Oak Ridge National Laboratory	1.	*Waste Acceptance Criteria For Radioactive Solid Waste Disposal at SWSA-6*, WMRA-WMPC-203, Martin Marietta Energy Systems, Inc., Oak Ridge Tennessee, April 1993.
DOE Savannah River	1.	*Savannah River Site Waste Acceptance Criteria Manual*, 1S Manual, Chapter 3.10, E-Area Vaults Low-Level Waste Acceptance Criteria, May 21, 1995.
DOE Hanford	1.	*Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-4 dated November 1993, through Page Change #3, dated May 17, 1995.

Table C-1. Comparison of non-DOE and DOE WAC.

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Physical Form	Solid, absorbed liquid, gas. --- 61.56(a)(2) 61.56(a)(7)	Solid, gas. --- SCL Condition 32(A) SCL Condition 34 SCL Condition 47 BSC 13.5 BSC 13.3	Solid, absorbed liquid, liquids (Class A only not to exceed 50 ml in vials used for clinical testing), gas. --- WAL Condition 28 WAL Condition 31 WAL Condition 32 WAL Condition 35	Solid, absorbed liquid, gas. --- Sec. 5.5.1.1	Solid, absorbed liquid --- Sec. 4.1.5 Sec. 4.2.3	Solid, absorbed liquid --- Sec. C.1.a Sec. C.1.c Sec. C.1.i	Solid, absorbed liquid, gas. --- Sec. 3.1.1.1 Sec. 3.1.1.4
Chemical Form	No explosive or gaseous reactions. --- 61.56(a)(4) 61.56(a)(5)	No xylene, toluene, dioxane, organic scintillation fluids or other organic liquids. Will accept Ecosint O, Opti-fluor, Ultima Gold, Ready-Safe, Ready Cap, Ready Filter, and Meltilex. No explosive or gaseous reactions. --- SCL Condition 43 BSC 13.5.4 SCL Condition 49 SCL Condition 50	No explosive or gaseous reactions. --- WAL Condition 22 WAL Condition 23	No explosives or gaseous reactions. --- Sec. 5.5.1.1(F) and (J) Sec. 5.5.2(C)	No explosives or gaseous reactions. --- Sec. 4.1.7 and 4.1.8	No explosives or gaseous reactions. >10 ppm benzene, toluene, ethyl benzene, and xylene are prohibited. --- Sec. C.1.f Sec. C.1.h Sec. C.1.n	No explosives or gaseous reactions. --- Sec. 3.1.1.2 Sec. 3.1.1.3

NOTE: References are contained in each criterion box below the dashed line following the paraphrased criterion. For exact wording of each criterion, refer to the appropriate source document(s) for that state, agency, or entity (see the reference documents found in the introductory comments to this comparison matrix).

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Liquid Limits	≤1% vol. HIC or ≤0.5% vol. for other waste. --- 61.56(a)(3) 61.56(b)(2)	≤1% vol. HIC or ≤0.5% vol. for other waste. --- SCL Conditions 32(A) through (C)	≤1% vol. HIC or ≤0.5% vol. for other waste --- WAL Condition 29 WAL Condition 30	≤0.5% vol. --- Sec. 5.5(2) and 5.5.1.1(C)	Free liquids shall not be disposed of. All liquids shall be solidified, permanently absorbed, or otherwise bound in the waste matrix by inert materials. --- Sec. 4.1.5	≤1% volume in a waste container or ≤0.5% volume for waste processed to a stable form. --- Sec. C.1.c	≤1% volume or ≤0.5% volume for waste processed to a stable form. --- Sec. 3.1.1.1
Void Space	Minimize --- 61.56(b)(3)	≤15% vol. for stable waste --- SCL Condition 39(C)	<15% vol. for stable waste --- WAL Condition 21	Minimize --- Sec. 5.5.1.2F	Minimize --- Sec. 4.4.5	Minimize --- Sec. C.1.u	<10% --- Sec. 3.7.1.1.1 Sec. 3.7.3.1.1 Sec. 3.7.3.2.1
Concentration Averaging	Yes --- 61.55(a)(8)	Yes, but not for sealed sources or filters encapsulated in solidification medium --- SCL Condition 31(a)	Yes, but not for filters encapsulated in a solidification agent --- WAL Appendix B Note 1				

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Packaging	No cardboard or fiberboard --- 61.56(a)(1)	No cardboard, corrugated paper, or fiberboard. Must be in wood, steel, or HIC. All packages must have proper lifting devices in place. --- BSC 8.7 BSC 8.8 BSC 8.9 SCL Condition 60 SCL Condition 61 SCL Condition 64	No cardboard, corrugated paper, fiberboard or wood. All packages must have proper lifting devices in place. --- WAL Condition 18 WAL Condition 25	Except for bulk waste, waste packaged in steel drums or SEALAND containers, the waste package (packaging and contents) shall be capable of supporting a uniformly distributed load of 19,528 kg/m^2. All packages must have proper lifting devices in place. --- Sec. 5.5.1.3(B) and (C)	No cardboard or fiberboard unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space. --- Sec.4.4.9	Factor of safety of 2:1 based on maximum load. Containers must be approved by disposal facility. --- Sec. C.7.c Sec. C.7.e	No cardboard or fiberboard boxes unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space. Package must be metal or shall be fire retardant. Packages must be able to withstand the weight of three layers of 55-gal drums (1,000 lb per drum). All packages must have proper lifting devices in place. --- Sec. 3.7.1.1.1 Sec. 3.7.1.2.7, 8 Sec. 3.7.2.3.1
Chelating Agents	>0.1% must be identified and estimated --- 20 App. F (I)	≤8% by weight. Between 0.1% and 8% must be stabilized. % applies prior to solidification. --- SCL Condition 46 BSC 13.16	Solidify or stabilize pretreatment concentration of >1% by weight --- WAL Condition 41	≤1% by weight --- Sec. 5.5.1.1(H)	≤0.1% by weight --- Sec. 4.2.5	>0.1% by weight must be stabilized; >1% by weight is prohibited. --- Sec. C.1.k Sec. C.1.l	>1% by weight must be stabilized and approved on a case-by-case basis. --- Sec. 3.1.2.4 Sec. 3.9.2.7

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Solidification Media	Test in accordance with Branch Technical Position on Waste Form --- BTP	Vinyl ester styrene, cement, full-formula oxidized bitumen, vinyl chloride for stable waste. Aquaset II-H and Petroset II may be used for Class A Unstable. --- SCL Conditions 33(A) through (E) BSC 13.5.2	Aztech, oxidized bitumen, concrete, vinyl ester styrene for stable waste. In addition to these, Atcor cement, Aquaset I and II, straight-distilled bitumen, Chem-Nuclear cement, structural concrete, Delaware Custom Media, Envirostone, LN Technologies Portland Cement for Oils, Pacific Nuclear Cement, Petroset I and II, Safe T Set, and SEG Cement may be used for Class A Unstable. --- WAL Appendix C WAL Appendix D	Chemical stability must be documented to show that significant quantities of harmful gases, vapors, or liquids are not generated. --- Sec. 5.5.1.1(F)	The waste form shall be stable under the presence of moisture, microbial activity, and internal factors such as radiation effects and chemical changes. --- Sec. 4.1.10		Category 3 LLW may be solidified using a NRC or WHC-approved process to meet stability criteria. Final processed waste must satisfy the performance criteria of the NRC Technical Position Paper on Waste Form. --- Sec. 3.5.2.3
Stability Requirements	HIC, inherent characteristics or process Class B and C --- 61.56(b)(1)	HIC, inherent characteristics or process Class B and C and A if it has nuclides with >5 yr half-life at ≥1 μCi/cc --- SCL Condition 33(B) SCL Condition 38 SCL Conditions 39(A) and (B) BSC 8.1 NOTE	HIC, inherent characteristics or process Class B and C and A if it is IX resin with ≥1 μci/cc of nuclides with >5 yr half-life (Co-60 can be ≤50 μci/cc) --- WAL Condition 26(D) WAL Appendix D WAL Appendix E WAL Condition 36	Where stabilization is required, it must be shown that the stabilization process is adequately controlled. Control is shown through the use of procedures, sampling, test plans, etc. and the results shall be made available for examination and approval. --- Sec. 5.5.1.1(F)	All liquids shall be solidified, permanently absorbed, or otherwise bound in the waste matrix by inert materials. --- Sec. 4.1.5		HIC, inherent characteristics as shown by analysis. All Category 3 waste must be stabilized. --- Sec. 3.5.2.1

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Sorptive Media	Allowable --- 61.56(a)(2)	Use only for incidental and unintentional liquid in otherwise dry solids --- SCL Condition 32(A) SCL Condition 34	May be used for liquids and listed in Appendix G of license WN-I019-2 Amendment 18. Includes many clays, diatomaceous earths, perlites, and others --- WAL Appendix G	Allowable, but types not specified. --- Sec. 5.5.1.1(C)	Allowable, but types not specified. --- Sec. 4.1.5	Allowable, but types not specified. --- Sec. C.1.c	Allowable, acceptable absorbents specified. --- Sec. 3.1.1.1 Sec. 3.9.1.1 Sec. 3.9.2.1 Appendix G
Oil		≤1% vol. trace and unintentional --- BSC 13.6 SCL Condition 52	Solidify or stabilize pretreatment concentration of >10% by weight --- WAL Condition 40		The absence of free liquids (including solvents and oils) must be certified for wastes which are in solid form. --- Sec. 4.2(1)	Materials >100 ppm total petroleum hydrocarbons are prohibited. --- Sec. C.1.m	Nonregulated free organic liquids will not be accepted. Absorbed or stabilized organic liquids may be accepted with evidence that the organic liquid will not facilitate migration of radionuclides. --- Sec. 3.1.2.3 Sec. 3.9.2.1
Gas	≤1.5 atm. at 20°C and max. 100 Ci --- 61.56(a)(7)	Kr-85 and Xe-133 at ≤1.5 atm. at 20°C and max. 100 Ci. Sealed tritium gas sources ≤1000 Ci. --- SCL Condition 47 BSC 13.3	≤1.5 atm. at 20°C and max. 100 Ci. --- WAL Condition 35	≤1.5 atm. at 20°C --- Sec. 5.5.1.1(E)	1.5 atm at 20°C. Unpunctured aerosol cans or gas cylinders are prohibited. --- Sec. 4.2(3) Sec. C.1.j	≤1.5 atm. at 20°C. Unpunctured aerosol cans or gas cylinders are prohibited. --- Sec. C.1.i Sec. C.1.j	≤1.5 atm. --- Sec. 3.1.1.4 Sec. 3.1.2.2

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Biological Waste	Must be treated to reduce biological, pathogenic, or infectious hazards --- 61.56(a)(8)	Must be in 4 mil. liner layered with slaked lime and ag grade 4 vermiculite or medium grade diatomaceous earth (ratio 30:1:10) and double packaged with absorbent in outside container --- BSC 13.2 SCL Condition 53	Must be in 4 mil. liner layered with absorbent (excluding perlites) and lime. Must be double packaged with absorbent in outside container --- WAL Condition 33 WAL Condition 34	Pathogens, infectious wastes, or etiologic agents as defined in 49 CFR 173.386 not accepted. Animal carcasses shall be layered with lime and placed in a metal container and, if capable of gas generation, vented with a carbon composite HEPA filtration device. --- Sec. 5.5.1.1(G) Sec. 5.5.5.6	Not accepted --- Sec. 7.1	Wastes contaminated with pathogens, infectious wastes, or other etiologic agents are prohibited. Animal carcasses shall be double bagged, sealed, placed in an approved container, and layered with absorbent and slaked lime. --- Sec. C.1.s Sec. C.4.g	Etiologic agents prohibited. Animal carcasses are accepted if packaged in 4-mil plastic within double-walled metal drum. Carcass must be in absorbent and lime with one part lime to 10 parts absorbent. --- Sec. 3.1.2.1 Sec. 3.9.2.8
Pyrophorics	Treat or package to be non-flammable --- 61.56(a)(6)	Must be treated or packaged to be non-flammable --- SCL Condition 51 BSC 13.7	Cannot react violently with water, moisture or agitation --- WAL Condition 23	Pyrophoric material in a form that may combust if the container is breached, will not be accepted. --- Sec. 5.5.1.1(J)	Pyrophoric materials shall be treated, prepared, and packaged to be nonflammable. --- Sec. 4.1.9	Pyrophoric wastes are prohibited. --- Sec. C.1.j	Pyrophoric wastes are prohibited. Must be treated, prepared, and packaged to be non-flammable. --- Sec. 3.1.1.5 Sec. 3.7.3.1.2
Source Material		60,000 pounds --- SCL Condition 5(B) SCL Condition 6(B) SCL Condition 7(B)	36,000 kgs. Will also accept large volume NORM of ≤0.002 μci/cc --- WAL Condition 6(B) WAL Condition 7(B) WAL Condition 8(B) WA Admin. Code 246-249-080 for NORM				

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Special Nuclear Material		200 g U-233 or 350 g U-235 max. in a package. --- NRCL Condition 1 BSC 13.8	60 g U-233 or 100 g U-235 or 60 g plutonium max. in a package --- NRCL 5(a)-(c) NRCL 6	The quantity of fissile radioactive materials shall be limited so that an infinite array of such packages will remain subcritical as determined by a specific nuclear safety analysis. --- Sec. 5.5.1.2(B)	≤1 g U-235 equivalent per standard package or the concentration of fissile isotopes shall be $<1 g/ft^3$ U-235 equivalent. --- Sec.4.1.3	≤50 U-235 gram equivalent per waste container. --- Sec. C.3	≤15 g of U-235 per waste package or a case-by-case Criticality Engineering Analysis is required. --- Sec. 3.7.3.2.6
Dimensions				4- x 4- x 7-ft or 4- x 2- x 7-ft or 55-gal drums are required to be used to allow optimum stacking efficiency, without special approval for other sizes. --- Sec. 5.5.1.3(D)	The following types of waste containers shall be used to collect and transport from the generator to the disposal facility: 30- or 55-gal black iron drums; 4x4x6 ft metal boxes; 1-, 2-, 5-, 10-, 20-gal cans, fiberboard boxes (DOT approved). If these do not provide adequate size, others may be used subject to approval. --- Sec. 4.4.6 and 4.4.10		Waste must be in Performance Oriented packaging that meets performance based requirements. Other packaging may be used if it meets container specific analyses (SARPs, SEPs, and DAPs). --- Sec. 2.5.1.2 and 2.5.2.1
Incinerator Ash		Must solidify, treat or package (with binding matrix) to be non-dispersible --- SCL Condition 45 SCL Condition 43	Must be solidified, granular or treated to be non-dispersible in air --- WAL Condition 39	Particulate wastes shall be immobilized so that the waste contains no more than 1 weight % of <10-μm-diam. particles, or 15 weight % of <200-μm-diam. particles. --- Sec. 5.5.1.1(D)		Particulate wastes shall be immobilized so that the waste contains no more than 1 weight % of <10-μm-diam. particles, or 15 weight % of <200-μm-diam. particles. --- Sec. C.1.e	

Table C-1. (continued).

Comparison of non-DOE and DOE low-level radioactive waste acceptance criteria (WAC) as of June 1995

WAC	NRC Requirement	Barnwell SC	Richland Washington	DOE NTS	DOE Oak Ridge	DOE Savannah River	DOE Hanford
Dewatered Resin	Yes --- 61.56(a)(3) 61.56(b)(2) BTP Section C.3 and C.4	Yes --- SCL Condition 36 SCL Condition 37 SCL Condition 38	Yes --- WAL Condition 28 WAL Condition 29 WAL Condition 36			Nitrated resins are prohibited. --- Sec. C.1.r	Yes --- Sec. 3.9.2.5
Transuranics		Activity must be evenly distributed and incidental. Accepts whole smoke detectors. --- SCL Condition 40 SCL Condition 41 BSC 13.10	Activity must be evenly distributed. Accepts whole smoke detectors and exempt consumer products. --- WAL Condition 37 WAL Condition 38	< 100 nCi/g specific activity in the waste. --- Sec. 5.5.1.1(A)	< 100 nCi/g specific activity in the waste. --- Sec. 4.2.6	< 100 nCi/g specific activity in the waste. --- Sec. 2, Table 2, Note (4)	< 100 nCi/g specific activity in the waste. --- Sec. 5.0

Appendix D

Comparison of DOE and Non-DOE Performance Assessment Requirements, Guidance, and Practices

Appendix D

Comparison of DOE and Non-DOE Performance Assessment Requirements, Guidance, and Practices

This appendix contains the DOE and non-DOE performance assessment information gathered to determine the differences in requirements, guidance, and practices. Because of the large volume of information it was not possible to put it all on one or two tables. The information was separated into six tables:

Table D-1. DOE performance assessment requirements and guidance.

Table D-2. Non-DOE performance assessment requirements and guidance.

Table D-3. DOE performance assessment practices, INEL (RWMC), and Hanford (200 West Area).

Table D-4. DOE performance assessment practices, ORNL (SWSA 6), and Savannah River Site (E-Area vaults).

Table D-5. Non-DOE performance assessment practices, Texas, California, and Nebraska.

Table D-6. Non-DOE performance assessment practices, North Carolina, Washington, and South Carolina.

The DOE performance assessment documents used were those that have been completed in at least a draft form and been reviewed by the performance assessment Peer Review Panel. Most of these documents have not been approved, work is continuing, and the information is subject to change.

Table D-1. DOE performance assessment requirements and guidance.

Parameter	Requirement	Guidance[a]
1.General 1.1 Format and Content 1.1.1 *What is the general format and contents of the PA?*	Field organizations with disposal sites shall prepare and maintain a site-specific radiological Performance Assessment (PA) for the disposal of waste for the purpose of demonstrating compliance with the performance objectives. General assumptions are required to determine the details of how the receptor is exposed because of the following requirements: "External exposure (of the receptor) to the radioactive material that may be released into surface water, ground water, soil, plants and animals results in an EDE that does not exceed ...," and "releases to atmosphere shall meet the requirements of 40 CFR 61." (DOE 5820.2A)	The recommended format and content of a PA is provided in DOE/LLW-62T[1] and DOE/LLW-81.[2] Additional recommendations are provided in DOE/LLW-93.[3]
1.2 Approval Process 1.2.1 *What is the formal process for final approval of the PA?*	PAs for new LLW disposal facilities are reviewed by the responsible field element and submitted to the Deputy Assistant Secretary (DAS) for Waste Management before construction begins. Waste Management staff evaluate the PA and peer review panel (PRP) review documentation; consult with the Office of Environment, Safety, and Health; and make a recommendation to the Assistant Secretary For Environmental Management regarding compliance with the performance objectives of DOE Order 5820.2A. The Assistant Secretary for Environmental Management approves the PA and authorizes construction of the disposal facility. Upon acceptance of the PA, the DAS for Waste Management prepares a Disposal Authorization Statement that sets forth the conditions for design, construction, and operation of the disposal facility that are appropriate to ensure compliance with the LLW performance objectives. (Interim Policy, Reference 22.) For existing LLW disposal facilities that continue to receive waste for disposal, PAs shall be reviewed by the responsible field element and submitted to the DAS for Waste Management for initial acceptance according to a schedule provided by the DAS for Waste Management. Waste Management staff evaluate the PA and PRP reviews; consult with the Office of Environment, Safety and Health; and make a recommendation to the DAS for	

a. The discussion included in the Guidance column often cites Reference 4, the *Performance Assessment Task Team Progress Report*. Readers should note that this document does not constitute official DOE guidance on how to prepare a performance assessment (PA). It does, however, represent the most recent (May 1994) documented recommendations of a DOE committee assembled to integrate the activities of the sites that are preparing PAs for disposal of low-level waste.

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
1.2 Approval Process 1.2.1 *What is the formal process for final approval of the PA?* (continued)	Waste Management about compliance with the performance objectives of DOE Order 5820.2A. Upon PA acceptance, the DAS for Waste Management shall prepare a disposal authorization statement that sets forth the conditions for operation of the disposal facility that may be appropriate to ensure compliance with the LLW performance objectives. (Interim Policy, Reference 22.) Before final closure of the disposal facility, or as otherwise directed, a final version of the PA shall be prepared, reviewed by the responsible field element, and submitted to the DAS for Waste Management for approval. (Interim Policy, Reference 22.)	
1.3 Review Process 1.3.1 *What formal review process does the PA go through before submittal for approval?*	PAs are reviewed by a PRP, at the request of the DAS for Waste Management. The purpose of this review is to ensure consistency and technical quality around the DOE complex in the development and application of performance assessment models that include site-specific geohydrology and waste composition. The PRP is selected by the DAS for Waste Management and is composed of DOE, contractor, and other specialists in PAs, with participation by representatives from the Office of Environment, Safety, and Health and operations offices. (Interim Policy, Reference 22.)	A preliminary and a final review of the PA is done by a PRP. After the final review the PRP issues a judgment of the technical quality of the PA to EM-30.[3]
1.4 PA Maintenance 1.4.1 *Does the PA need to be reviewed and updated if parameters change?*	Field offices having a disposal facility PA accepted by the DAS for Waste Management shall conduct a PA maintenance program during the operational period of the disposal facility. In addition, PAs shall be reviewed and revised when changes in waste forms or packaging, radionuclide inventories, facility design, closure concepts, or the understanding of the site or other features change the conclusions of the existing PA. On an annual basis, or as otherwise required, field offices will make a determination of the continued adequacy of the PA based on waste receipts, the results of monitoring or test programs, and other relevant factors. The determination must be documented and made available for inspection. (Interim Policy, Reference 22.)	

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
1.5 Method for Evaluating Uncertainty 1.5.1 *Is the method deterministic or probabilistic and what kind of uncertainty or sensitivity analysis is used?*	There is no statement in DOE 5820.2A that is related to uncertainty of the PA. The method of determining compliance with the performance objective is normally deterministic since the PA usually provides a single dose for comparison. Uncertainties are discussed in the PA, but the final calculated dose does not normally include a range of doses based on the uncertainties or the sensitivities.	Sensitivity of the PA results to various model assumptions and the analysis of uncertainty in the PA results will be reviewed by the PRP.[3] Guidelines on the performance of uncertainty analyses and sensitivity analyses is provided in DOE/LLW-62T.[1]
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process? Is there a list of pre-approved codes?*	There is no requirement or approval process for PA codes. Their results are approved as part of the PA approval process. There are no codes pre-approved for PA use.	The PA must include a discussion of the rationale for selecting the computer codes that were used in the assessment.[3] The PRP reviews the justification for using the codes. Many pages of discussion on selection and sources of PA computer codes is provided in DOE/LLW-62T[1] and DOE/LLW-157.[4] A listing of DOE and EPA PA modeling codes is also provided, however, the discussion states that these codes are too simplistic because they model the system with rather simplified descriptions of actual physical processes and/or with simplified submodels in order to make computer modeling feasible for an entire complex system.[1]
1.6.2 *Does the code approval process include validation and/or verification?*	Not applicable.	A combination of verification and benchmark testing can be used to build confidence in the ability of the code and embodied model(s) to simulate macroscopic (plume scale) behavior of a site-specific disposal system. Such testing is necessary for all codes used in support of a PA.[4]
2. Receptor (most exposed individual 2.1 Receptor Scenario 2.1.1 *What general assumptions are required?*	None.	For compliance with the dose objectives the maximally exposed individual, during the periods of operations and institutional control, shall be a hypothetical adult individual residing at or near the DOE site boundary at the location of maximum exposure to radionuclides.[1] The maximally exposed individual is assumed to be the ICRP reference man model. (DOE 5400.5)
2.1.2 *What site-specific assumptions are used?*	Not applicable.	See site-specific practices.

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
2.1.3 *Are variations used to model against possible future environmental conditions?*	There is no requirement on this in DOE 5820.2A.	Each site PA should consider the effects of expected long-term changes to the degree that such changes may significantly impact the isolation capability of their disposal systems within the time period covered by the PA. Events and processes with small impact and probability should be omitted. Generally a qualitative discussion will suffice.[4] To demonstrate compliance with the performance objectives, long-term calculations based on present conditions (including present rates of natural processes such as erosion) should be carried out.[4]
2.2 Dose Standard 2.2.1 *What is the dose standard (performance objective) for the most exposed individual?*	Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, ground water, soil, plants and animals results in an EDE that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Protect ground water resources, consistent with Federal, State and local requirements. (DOE 5820.2A)	The PATT recommends that, "Disposal systems shall be designed, operated, closed, and controlled after closure to provide reasonable assurance that the annual EDEs to individual members of the public beyond the boundary of the disposal site will not exceed 25 mrem (0.25mSv) from all exposure pathways." Determinations of reasonable assurance shall be left to the judgement of the PRP and other reviewers.[4]
2.3 Point of Compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	There is no requirement on this in DOE 5820.2A.	Outside the buffer zone, which shall be defined in the site-specific PA but shall not extend more than 100 m from any disposal unit. However, during the period of active institutional control over the disposal site, it may be assumed, with proper justification given in the PA, that control will be maintained over a larger region.[4]
2.4 Time of Compliance 2.4.1 *What is the time of compliance (time certain or peak dose)?*	There is no requirement on this in DOE 5820.2A.	The PA shall identify the likely natural processes and events that may affect the disposal system, examine the effects of these processes and events on the disposal system, and estimate potential exposures for a period of 10,000 yr.[4] The DOE steering committee for the revision of DOE 5820.2A has chosen 1,000 years, rather than 10,000 years, as the time of compliance. Neither recommendation is officially approved.
2.4.2 *What assumptions are made about future land ownership/control?*	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period. (DOE 5820.2A)	

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
2.4.3 *What institutional control period is specified?*	The institutional control period is defined in DOE 5820.2A as, "A period of time, assumed to be about 100 yr, during which human institutions continue to control waste management activities."	Active institutional controls include fences, patrols, alarms, monitoring instruments, and other activities requiring active attention, enforcement, and interdiction. It is generally agreed that the active institutional controls should not be relied upon for more than 100 yr. If protection beyond that time is needed, passive controls (both institutional and engineered features) may be provided. Passive institutional controls may include land use restrictions, government ownership, site dedication to nonintrusive uses, and other passive institutional means to limit access to the waste. Passive controls also include engineered features, such as long-lived markers, engineered barriers, special waste forms, burial depth, and special materials incorporated into the site closure system.[4]
2.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	None.	Passive controls, including both engineered features and institutional controls, (e.g., physical barriers, markers, long-term government ownership and control, and use restrictions), may be incorporated into the design to provide reasonable assurance that the performance objectives will be met. The time of effectiveness of passive controls must be specified and justified in the PA.[4]
2.5 Dose Conversion 2.5.1 *What requirements or standards are used to determine dose conversion factors?*	The doses calculated in the PA are evaluated per the requirements of DOE 5400.5, Chapter II, Sections 6b(2)(a) and (b). The internal conversion factors are based upon the ICRP reference man model, and the committed dose is the dose integrated over an interval of 50 yr. It should be noted that these sections of DOE 5400.5 reference the same documents that are referenced in the guidance.	The calculation of doses from the LLW facility should follow recommendations of the International Commission of Radiological Protection and should use dose conversion factors from DOE/EH-0070[6] and DOE/EH-0071[7] or those provided by the EPA in RFG-11.[8] This guidance is from reference 3.

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
3. Receptor (inadvertent Intruder) 3.1 Receptor Scenario 3.1.1 *What general assumptions are required?*	There is no mention of intruder scenarios in DOE 5820.2A.	The PATT endorses the general types of exposure scenarios that were developed by the NRC and recommends that dose assessments for inadvertent intruders consider the following types of scenarios involving either chronic exposures over a lifetime or a single, acute exposure: (1) An acute construction scenario and a chronic agriculture (homesteader) scenario. (2) An acute discovery scenario and a chronic resident scenario. (3) An acute drilling scenario and a chronic post-drilling scenario. However, the PATT does not recommend that standard definitions of these scenarios be used at all DOE disposal sites. Rather the PATT recommends that the definition and application of exposure scenarios for inadvertent intruders be tailored to the particular characteristics of the waste, disposal facility, and disposal site, with adequate justifications provided in the PA.[4]
3.1.2 *What site-specific assumptions are used?*	Not applicable.	The intruder scenarios must be appropriate for the environment of the site. Some examples of site-specific assumptions would be; the definition of exposure scenarios, the choice of exposure pathways and pathway models, and the selection of model parameter values.[4]
3.1.3 *Are variations used to model against possible future environmental conditions?*	There is no mention of intruder scenarios in DOE 5820.2A.	Each site PA should consider the effects of expected long-term changes to the degree that such changes may significantly impact the isolation capability of their disposal systems within the time period covered by the PA. Events and processes with small impact and probability should be omitted. Generally a qualitative discussion will suffice.[4] To demonstrate compliance with the performance objectives, long-term calculations based on present conditions (including present rates of natural processes such as erosion) should be carried out.[4]

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
3.2 Dose Standard 3.2.1 *What is the dose standard for the most exposed hypothetical inadvertent intruder?*	Assure that the committed EDEs received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 yr) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure. (DOE 5820.2A)	The PATT has debated two options for the intruder dose objective in DOE 5820.2A. The Order states this as a performance objective, parallel to the objective for protection of the general public, requiring an analysis of intrusion scenarios against the specified dose objective. The alternative suggested is to use an analysis of potential dose to a hypothetical inadvertent intruder as the basis for setting site-specific WAC, similar to the NRC procedure for developing waste classes for 10 CFR 61. The current direction of the PATT opinion is toward using potential dose to a hypothetical intruder as the basis for setting site-specific WAC, but the issue remains under discussion.[4]
3.3 Point of Compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	Not covered as a requirement. The intruder scenarios are site-specific.	The intruder scenarios that are required to be used generally assume that the individual is located directly above the waste and has brought some of the radionuclides to the surface during their occupancy.
3.4 Time of Compliance 3.4.1 *What is the time of compliance (time certain or peak dose)?*	After 100 yr (DOE 5820.2A).	The PA shall include the calculation of the maximum projected impact to an inadvertent intruder during the post-institutional control period. The time period may last more than 500 yr, depending on the time of maximum impact.[1]
3.4.2 *What assumptions are made about future land ownership/control?*	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period. (DOE 5820.2A)	
3.4.3 *What institutional control period is specified?*	The institutional control period is defined in DOE 5820.2A as, "A period of time, assumed to be about 100 yr, during which human institutions continue to control waste management activities."	Active institutional controls include fences, patrols, alarms, monitoring instruments, and other activities requiring active attention, enforcement, and interdiction. It is generally agreed that the active institutional controls should not be relied upon for more than 100 yr. If protection beyond that time is needed, passive controls (both institutional and engineered features) may be provided. Passive institutional controls may include land use restrictions, government ownership, site dedication to nonintrusive uses, and other passive institutional means to limit access to the waste. Passive controls also include engineered features, such as long-lived markers, engineered barriers, special waste forms, burial depth, and special materials incorporated into the site closure system.[4]

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
3.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	Not applicable.	It is intended that disposal systems shall be designed to provide reasonable assurance that the potential dose to individuals who may inadvertently intrude into the facility after the active institutional control period (taken to be 100 yr after closure) will not exceed 500 mrem for a single exposure or 100 mrem per yr for exposure continuing over several years. Passive controls, including both engineered features and institutional controls, (e.g., physical barriers, markers, long-term government ownership and control, and use restrictions), may be incorporated into the design to provide reasonable assurance that the performance objectives will be met. The time of effectiveness of passive controls must be specified and justified in the PA.[4]
3.5 Dose Conversion 3.5.1 *What requirements or standards are used to determine dose conversion factors?*	The doses calculated in the PA are evaluated per the requirements of DOE 5400.5, Chapter II, Sections 6b(2)(a) and (b). The internal conversion factors are based upon the ICRP reference man model, and the committed dose is the dose integrated over an interval of 50 yr. It should be noted that these sections of DOE 5400.5 reference the same documents that are referenced in the guidance references 6, 7, and 8.	The calculation of doses from the LLW facility should follow recommendations of the International Commission of Radiological Protection and should use dose conversion factors from DOE/EH-0070[6] and DOE/EH-0071[7] or those provided by the EPA in RFG-11.[8] This guidance is from reference 3.
4. Release Mechanism 4.1 Waste Inventory 4.1.1 *What are the requirements for keeping records on waste inventory?*	Each field organization shall develop and maintain a record keeping system that contains information on the waste generated, treated, stored, shipped, or disposed of at its facilities. The information shall include all data necessary to show that the waste was properly classified, treated, stored, shipped, or disposed of. The data shall be based on the data recorded on waste manifests. Waste manifests will be kept as permanent records. (DOE 5820.2A) Requirements on retention and storage of the records are found in the DOE 1324 series of DOE Orders.	A shipment manifest or shipping paper must accompany each package of radioactive waste from a generator to a treatment, storage, or disposal facility. The manifest must include information on waste characteristics, including a physical description of the waste, the waste's volume and mass, each radionuclide's identity and quantity, total radioactivity, the principal chemical form, and the solidification agent (if any). As a minimum, the quantity of each of the radionuclides H-3, C-14, Tc-99, and I-129 must be listed. The manifest must also identify waste containing more than 0.1% by weight chelating agents, and an estimate of the weight percentage and identity of the chelating agent.[9] Additional guidance on manifest reporting is given in Tab M of reference 9.
4.1.2 *How do current requirements for keeping records differ from past requirements?*	Requirements for keeping records on waste shipments for disposal prior to the issuance of DOE 5820.2A (September 26, 1988) are not available.	No historical guidance on keeping records for waste disposal are known.
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory for purposes of the PA?*	None.	None.

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
4.2 Source Term 4.2.1 *What assumptions are made about the release mechanisms of radionuclides from the various waste forms?*	None.	The PA should describe the transport/pathway scenario under which radionuclides contribute to offsite doses to individuals. This scenario must identify the release mechanism. Examples of release mechanisms are: material leaching, ground surface contamination or runoff, and complex pathways that include combinations of these. A complex pathway may include biotic uptake of contaminants with subsequent intake by humans.[3]
4.2.2 *For purposes of the PA during operations or for closure, is all waste included in the source term?*	DOE LLW that has not been disposed of prior to September 26, 1988 shall be managed to meet the performance objectives. (DOE 5820.2A) Note: A memorandum from J.E. Lytle, Deputy Assistant Secretary for Waste Management and Environmental Management, dated May 31, 1995, states, "With the issuance of this memorandum, we are establishing a requirement that Operations Offices must include within the scope of performance assessments for active and planned LLW disposal facilities an analysis of other source terms that potentially add to the doses calculated for the receptor. Therefore, LLW disposed of prior to September 26, 1988, as well as other sources of radioactive contamination in the ground (e.g., spills, leaks, liquid discharge plumes), are to be included in performance assessments." The memorandum also states, "This directive is to remain in effect until the appropriate requirements are incorporated into a waste management order."	The PA guidance does not differ from the DOE 5820.2A requirement.
4.2.3 *What is the source of scaling factors for indirectly measured radionuclides?*	The concentration of radionuclides may be determined by indirect methods such as the use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured if there is reasonable assurance that the indirect method can be correlated with actual methods. (DOE 5820.2A)	Generators may establish an inferential measurement program whereby concentrations of radioisotopes that cannot be readily measured (through techniques such as gamma-spectroscopic analysis) are projected based on concentrations of radioisotopes that can be readily measured. An example would be the practice of scaling transuranic concentrations to concentrations of the isotope Ce-144. Scaling factors should be developed for facilities and waste streams on an individual basis, and should be initially determined and periodically confirmed through direct measurements.[9]

Table D-1. (continued).

Parameter	Requirement	Guidance[a]
5. Pathways 5.1 Site Characteristics 5.1.1 *Must data about site characteristics meet any quality requirements in order to be used in the PA?*	Disposal site selection shall be based on an evaluation of the prospective site in conjunction with planned waste confinement technology, and in accordance with the NEPA process. (DOE 5820.2A) Consistent with DOE 5700.6B, the LLW operational and disposal practices shall be conducted in accordance with applicable requirements of ANSI/ASME NQA-1 and other appropriate national consensus standards. (DOE 5820.2A)	Because of the Quality Assurance (QA) requirements, all aspects of the PA should be conducted under a written Quality Assurance/Quality Check (QA/QC) program. However, use of earlier data obtained without the guidance of a QA/QC program is not precluded. If such data are used, the effect of the lack of QA/QC shall be discussed in the analysis of uncertainty. Reference 9, Tab L, provides additional information and references on QA.[3] The PA data base shall be documented in a manner that will allow evaluation of data representativeness, accuracy, precision, and ranges of applicability. Data quality is achieved when there is sufficient documentation of the data to ensure auditability and traceability.[4]
5.1.2 *What requirements are there to avoid the potential for "masking" from nearby nuclear facilities?*	Monitoring measurements to evaluate actual and prospective performance should be made at locations within and outside each facility and disposal site. Monitoring should also be used to validate or modify the models used in the PA. (DOE 5820.2A) The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. The monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meet the requirements of applicable EH Orders. (DOE 5820.2A)	A monitoring program must provide for identification of the origin and sources of radioactive materials, chemically hazardous substances, and chemical indicators of migration in the environment. The monitoring program must also identify reasons for any change in concentrations of these materials.[5]
5.2 Waste Distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to the most exposed individual?*	None.	The waste is assumed to be uniformly distributed.[4]
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to a hypothetical inadvertent intruder?*	None.	The waste is assumed to be uniformly distributed.[4]

Table D-2. Non-DOE Performance Assessment Requirements and Guidance.

Parameter	Requirement	Guidance
1. General 1.1 Format and content 1.1.1 *What is the general format? What are the contents for the PA?*	10 CFR 61.10, et seq., specifies contents for license applications. While the term, "performance assessment" is not used, the contents specify that an applicant show the "pathways analyzed in demonstrating protection of the general population from releases of radioactivity," which include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals" (61.13a). The applicant must also show that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided (61.13b).	Guidance on the expected format for a disposal facility license application is provided in the document, "Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility," (NUREG-1199). The chapter of the document on Safety Assessments outlines the expected contents of a performance assessment based on releases of radioactivity. This includes determining the types of waste to be disposed, avenues for radionuclide release, and mechanisms for transfer of radionuclides to humans.
1.2 Approval process 1.2.1 *What is the formal process for final approval?*	Before a commercially-operated disposal facility can operate, it must receive an operating license from the NRC or an Agreement State that meets NRC requirements through a period audit process. The same agency that licenses the facility regulates it on an ongoing basis. The performance assessment is approved as part of the application for a disposal license. The process for review and approval of a license application is described in 10 CFR Part 2, Subpart A.	The Standard Review Plan (NUREG-1200) provides guidance to NRC staff for reviewing applications for disposal facilities. Chapter 6, Safety Assessment, parallels the contents of the same chapter in the Standard Format and Content Guide, NUREG-1199. The assessment structure is divided into three parts: radioactivity release, transfer, and dose. NUREG-1274 provides information on the procedural aspects of the license application review process, but does not specifically address procedures for reviewing performance assessments.
1.3 Review process 1.3.1 *What formal review process does the PA go through before submittal for approval?*	None	None
1.4 PA maintenance 1.4.1 *Is PA reviewed and updated as parameters change?*	10 CFR 61.80(i) requires that a disposal facility licensee report to the NRC (or agreement state agency) if radioactive releases or monitoring results "are significantly different from those expected in the materials previously reviewed as part of the licensing action."	A proposed NRC BTP on Performance Assessment, section D.5, recommends that licensees develop a "framework for determining the value and impact of ...new information on the calculation of concentrations and doses."
1.5 Method for Evaluating Uncertainty 1.5.1 *Deterministic or probabilistic? What kind of uncertainty or sensitivity analysis, if any?*	None	NUREG-1199 (Section 6.1.5.1.), a draft Branch Technical Position (BTP) on Performance Assessment dated January 1994, and other NRC guidance recommends that uncertainty and sensitivity analyses be conducted in order to determine that there is reasonable assurance that performance objectives will be met. The draft BTP recommends that an approach known as "probabilistic risk assessment" be used. Under this approach, the results of a number of separate computer runs using a wide range of values and assumptions are considered collectively to establish a frequency distribution for the dose to an individual.

Table D-2. (continued).

Parameter	Requirement	Guidance
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process, itself?*	In the license application review process, the code itself is not approved. Approval of a license application implies that a code was appropriate for the use intended.	The NRC in the past has issued technical reports that evaluate and recommend specific computer codes for specific purposes. See NUREG/CR-5453, v.5, "Computer Code Implementation and Assessment." Until early 1995, the NRC Low-Level Radioactive Waste office conducted topical reports on a cost recovery basis, at the request of individuals and organizations. The final topical report, before the NRC discontinued this program, was evaluation and approval of the 3R-Stat code for estimating concentrations of I-129 and Tc-99 using scaling factors.
1.6.2 *Does the code approval/review process include Validation? Verification?*	None	NUREG 1199, in several places in Section 6, recommends that an applicant "describe and justify the type of model(s) used, the theoretical basis of each model." This should include "the procedures used to verify the codes and the methods for and results of model calibration...including model validation techniques and sensitivity analyses."
2. Receptor (most exposed individual) 2.1 Receptor scenario 2.1.1 *What are the general (non-site-specific assumptions?)*	None	The draft BTP on PA, Section E.1., describes the recommended general scenario: The "maximally exposed individual" is assumed to reside at the site boundary, where offsite exposures to radionuclides released to air and water are expected to be greatest, and consumes locally grown food crops irrigated with contaminated ground-water withdrawn at the site boundary.
2.1.2 *What site-specific assumptions are used?*	None	The draft BTP on PA advises that the basic scenario be tailored to meet conditions at a specific site. For example, the groundwater well should be located at a point along the site boundary that produces the maximum groundwater concentration.
2.1.3 *Does the PA model make any assumptions about future environmental conditions (such as global warming) that are different from today's environmental parameters?*	None	The draft BTP on PA, Section D.1., states that "the uncertainty of future climate changes makes long-range projections on the scale of thousands of years impossible. To the extent that the natural and climatic history and geography of a site are known, there is a basis for projecting what the succession of vegetation at the site may be and for developing a reference biosphere for the PA model. Nevertheless, given the uncertainty in projecting timing and extent of climatic change, an approach for biosphere changes that bounds the current trends should be considered sufficient. The analyst may assume that the reference biosphere is present throughout the period of performance that is analyzed.

Table D-2. (continued).

Parameter	Requirement	Guidance
2.2 Dose standard 2.2.1 *What dose value to the individual is the standard?*	10CFR61.41 requires that the dose received by any member of the public from all pathways not exceed an annual dose of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ.	The EPA is considering regulations (40 CFR 193) that would impose a dose standard of 15 mrem EDE, consistent with ICRP 26/30. The EPA recently announced that the proposed rule would apply to DOE sites but not to NRC or State licensees.
2.3 Point of compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	10CFR61.52(a)(8) specifies that a "buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste.	NUREG-1200, section 4.3.6, recommends that the buffer zone be at least 30 m wide (approximately 100 ft) around the entire facility. NUREG-1199, section 6.1.6, describes typical receptor points for various scenarios of "offsite releases" for various pathways. These include the site boundary; the nearest user of groundwater down gradient of the site; the nearest surface discharge point down gradient from the site; the nearest surface discharge point (e.g., stream); and the nearest resident (assumed to be at the site boundary during the active and passive institutional control periods).
2.4 Time of compliance 2.4.1 *What is the time of compliance? (Time certain or peak dose?)*	None	NUREG-1199, section 6.1.6, specifies that potential normal offsite releases be controlled to within regulatory standards, and be maintained as low as reasonably achievable, "during the operational, closure, observation and surveillance, active institutional control, and passive institutional control periods." The draft BTP on Performance Assessment, section D.3.3, states, however, that "a performance assessment analysis carried out to peak dose, even if it occurs over long timeframes, provides information about the relationships between the inventory of long-lived radionuclides (and daughters), the site characteristics (under current conditions) and the potential hazard to future generations for different scenarios." The BTP goes on to recommend that doses be calculated at the end of the passive institutional control period; at 10,000 yr; and to peak dose following 10,000 yr unless the applicant can demonstrate that the remaining inventory at the site would not result in the dose standard being exceeded.

Table D-2. (continued).

Parameter	Requirement	Guidance
2.4.2 *What assumptions are made about future land ownership/control?*	10 CFR 61.14(b) requires that, "Where the proposed disposal site is on land not owned by the Federal or State government, the applicant must submit evidence that arrangements have been made for assumption of ownership in fee by the Federal or State government..." At the end of the prescribed period of institutional control, the license will be terminated (10 CFR 61.7(c)(4)). At that point, for purposes of performance assessment, institutional control is assumed to be lost.	
2.4.3 *What institutional control period is used?*	10 CFR 61.59 requires that institutional controls not be relied upon (to avoid exposures to the maximally exposed individual) for more than 100 yr following transfer of control of the disposal site to the owner (i.e., the 5-yr closure period).	NUREG-1200, section 6.1, states "There is no fixed limit to the length of the institutional control period. However, for purposes of analysis of site performance, the institutional control period is separated into an "active" and a "passive" period. During the active period, which should normally be assumed to last no more than 100 yr, the above custodial activities may be assumed to be carried out by the site owner. The passive period follows the active period, and during this period it should be assumed that relatively few custodial activities are carried out."
2.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	During the 100-yr institutional control period, it is assumed that ongoing monitoring will be sufficient to identify and remediate conditions that would allow offsite releases in excess of the dose standard. [10 CFR 61.7 and 61.59(a)]	Although institutional controls (such as the fence around the site boundary) may not be relied upon for more than 100 yr following transfer of control of the disposal site to the state (10CFR 61.59(b)), an applicant may assume, for purposes of modeling, that the "most exposed individual" remains outside the institutional control area after 100 yr. (See point of compliance, above.) NUREG-1199, section 6.1.2, states that a license applicant should provide and defend values for the infiltration rates through the disposal facility cover, which may be considered a passive control following the institutional control period.
2.5 Dose conversion 2.5.1 *What is the source of dose conversion factors? What assumptions are used?*	None	External beta/gamma exposures due to proximity to uniformly contaminated surfaces, and beta/gamma exposures due to immersion in contaminated air may be based on the methodology presented in NUREG/CR-1918, or an equivalent methodology. Exposures to internal organs due to ingestion or inhalation pathways should be based on the methodology in International Commission on Radiological Protection, Publication 30, or its equivalent. (NUREG-1199, section 6.1.6)

Table D-2. (continued).

Parameter	Requirement	Guidance
3. Receptor (inadvertent intruder) 3.1 Receptor scenario 3.1.1 *What are the general (non-site-specific assumptions?*	The concentration limits in 10 CFR 61.55 for LLW disposed in near-surface facilities were set at levels that could be allowed in waste so that the dose equivalent received by an intruder would not exceed the 500-mrem limit. For Class A waste, the concentration limit was set so the intruder would not receive the 500-mrem dose equivalent (whole body and bone; 1,500 mrem for other organs) based on intruder-agriculture or intruder construction scenarios at 100 years; the limits for Class B were based on intruder-discovery scenarios at 100 years; and the limits for Class C were based on intruder-agriculture or intruder-construction scenarios at 500 years. All calculations were based on uniform waste concentrations in the trench. For Class C waste, it is assumed that disposal at greater depth (at least 5 m) is sufficient to isolate the waste from an inadvertent intruder. Where site conditions prevent deeper disposal, measures to prevent an intruder from coming into contact with the waste for 500 yr must be provided. Calculation of the 500 mrem potential dose was done at 500 yr following closure of the site, assuming that the intruder barrier is no longer effective. (EIS for 10 CFR 61, NUREG 0945, Nov.1982, Vol. 1, p.5-25; also 10 CFR 61.7(b))	An applicant should provide information on intruder protection measures that would prevent an intruder from coming into contact with Class C waste after the institutional control period. (NUREG-1199, section 6.2)
3.1.2 *What site-specific assumptions are used?*	"Analyses of the protection of individuals from inadvertent intrusion must include demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided." (10 CFR 61.13)	It is recommended that a license applicant provide information and analyses on the engineering features of the intruder protection system and on waste handling and segregation practices that will ensure that a potential inadvertent intruder will not come into contact with Class C waste during the 500-yr period of performance. Where the applicant relies on additional disposal depth to isolate the intruder from the waste, the applicant must provide engineering details on the type of material used as backfill and field controls used in its placement. (NUREG-1199, section 6.2)
3.1.3 *Are variations used to model against possible future environmental conditions?*	No. The waste classification system is designed to limit doses to inadvertent intruders under the range of environmental and other conditions considered in the preparation of the EIS for 10 CFR 61.	

Table D-2. (continued).

Parameter	Requirement	Guidance
3.2 Dose standard 3.2.1 *What dose value to the individual is the standard?*	The annual dose equivalent limit to the inadvertent intruder is 500 mrem and was used by the NRC to develop the classification limits (see 3.1). This limit also includes a value of 1500 mrem/yr for organs other than bone.	In setting the limits in the classification tables and prescribing disposal practices for each class of LLW, the NRC used a 500 mrem annual dose limit to a person who inadvertently intrudes into the Class A disposal units after the 100-yr active institutional control period, or who intrudes into a Class C disposal unit after 500 yr. The dose equivalent limit also included a value of 1500 mrem/yr for organs other than bone. (See Requirements for *Receptor Scenario* for the inadvertent intruder, above.)
3.3 Point of compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	At or over the disposal units.	(See Requirements for *Receptor Scenario* for the inadvertent intruder, above.)
3.4 Time of compliance 3.4.1 *What is the time of compliance? (Time certain or peak dose?)*	(Waste classification is based on exposure levels at 100 yr for Class A LLW and 500 yr for Class C LLW. See above.)	(See Requirements for *Receptor Scenario* for the inadvertent intruder, above.)
3.4.2 *What assumptions are made about future land ownership and control?*	At the end of the prescribed period of institutional control, the license will be terminated (10 CFR 61.7(c)(4)). At that point, for purposes of performance assessment, institutional control is assumed to be lost.	
3.4.3 *What institutional control period is used?*	"Institutional controls may not be relied upon (for protection of an inadvertent intruder) for more than 100 yr following transfer of control of the disposal site to the owner (the state or federal government)" (10 CFR 61.59(b))	
3.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	While passive controls, such as permanent trench markers, are required, they cannot be relied upon, for purposes of site evaluation, to deter an inadvertent intruder after the 100-yr active institutional control period. An applicant may demonstrate, however, that an engineer intruder barrier or additional depth to Class C waste would deter a potential intruder (*see Intruder Scenarios*, above.)	
3.5 Dose conversion 3.5.1 *What is the source of dose conversion factors? What assumptions are used?*	The dose conversion factors used by the NRC to calculate the LLW classification limits were from ICRP-2.	Probably not applicable since the NRC used these dose conversion factors to calculate the LLW classification limits. Doses to an inadvertent intruder are not required to be calculated by a licence applicant.

Table D-2. (continued).

Parameter	Requirement	Guidance
4. Release Mechanism 4.1 Waste inventory 4.1.1 *How are records on waste inventory kept to ensure their integrity?*	10 CFR 61.80 specifies requirements for retention and periodic transfer of waste inventory records to the state or federal regulatory agency. The requirements for quality assurance under 10 CFR 61.12(j) specify that the QA program cover the operations period, as well as the construction and closure periods. Guidance on document control stem from these QA requirements.	NUREG-1199, section 9.1.6, states that applicants should describe the measures established to control documents that prescribe activities affecting the quality of the design, construction and *operation* of a LLW facility. (This presumably includes records on the waste inventory disposed of in the disposal units.)
4.1.2 *For currently operating sites, how does record keeping today differ from the past?*		
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory, for purposes of PA?*		
4.2 Source term 4.2.1 *What assumptions are made about the release of radionuclides from the various waste forms?*	None	NUREG-1199, section 6.1.3, states that applicants should provide a "reasonable, but conservative, assessment of radioactivity release into each of the most significant radioactivity transport mechanisms..." While the document includes a table illustrating typical release scenarios, it indicates that these are only illustrative and states that applicants should provide an "analysis that identifies and quantifies the most significant scenarios based on the specific details of the site environment, the facility waste acceptance criteria, and the facility design and operating practices."
4.2.2 *For purposes of PA during operations or for closure, is all waste included in the source term?*	Three commercial disposal sites were operating under Agreement State licenses at the time 10 CFR 61 was issued in final. In the Federal Register Notice presenting the regulation (47 FR 57463), "the phasing in of the Part 61 requirements" was discussed. The discussion concluded that the following sections and subparts would be considered a matter of compatibility for the Agreement States: The Definitions, Performance Objectives, Technical Requirements, and certain other parts. Since the performance objectives (e.g., protection of the general population from doses exceeding 25-75-25) were evidently imposed retroactively on the already-operating sites, all waste disposed prior to issuance of the regulation apparently is to be considered in performance assessment.	

Table D-2. (continued).

Parameter	Requirement	Guidance
4.2.3 *What is the source of scaling factors for indirectly measured radionuclides?*	10 CFR 61.55(a)(8) specifies that "The concentration of a radionuclide may be determined by indirect methods such as the use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured..."	NUREG-1199, section 6.1.1, states that applicants should provide projections of the physical, chemical and radiological characteristics of each waste stream to be disposed of at the proposed facility. This information should include average concentrations of the principal radionuclides constituting the waste stream.
5. Pathways 5.1 Site characteristics 5.1.1 *Must data about site characteristics meet any quality requirements or standards in order to be used in PA?*	10 CFR 61.12(j) requires applications for disposal facility operating licenses to include information on the their quality assurance program for determining the natural disposal characteristics of the proposed site.	NUREG-1199; NUREG-1293, Quality Assurance Guidance for Low-Level Radioactive Waste Disposal Facility; and DOE/LLW-150, Generic Quality Assurance Plan, provide guidance on the framework for a comprehensive QA program.
5.1.2 *What is done to avoid the potential for "masking" from nearby nuclear facilities?*	10 CFR 61.50(11) requires that, "The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of (this part) or significantly mask the environmental monitoring program." 61.53(a) requires that, "At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics...(c) The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.	
5.2 Waste distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Most Exposed Individual?*	None	None
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Inadvertent Intruder?*	None	None

Table D-3. DOE Performance Assessment Practices for INEL (RWMC) and Hanford (200 West Area).

Parameter	INEL (RWMC)	Hanford (200 West Area)
1. General 1.1 Format and Content 1.1.1 *What is the general format and contents of the PA?*	The general format and content of the PA[12] follows the recommendations in DOE/LLW-81[2] very closely and also considers the guidance in DOE/LLW-62T.[1]	The format and content of the PA[14] generally follows DOE/LLW-81[2] with some minor modifications to Section 3, Analysis of Performance and Section 4, Results of Analysis.
1.2 Approval Process 1.2.1 *What is the formal process for final approval of the PA?*	Not applicable	Not applicable
1.3 Review Process 1.3.1 *What formal review process does the PA go through before submittal for approval?*	Not applicable	Not applicable
1.4 PA Maintenance 1.4.1 *Does the PA need to be reviewed and updated if parameters change?*	The PA[12] includes a section that discusses needs for enhancement of data and environmental monitoring to improve the confidence in the assumptions and the results of the PA. Some of the needs are currently being or are planned to be addressed.	The PA[14] says very little about a PA maintenance program. However, it does state (page 5-4) that, as part of a PA maintenance program specified data should be collected and evaluated periodically to determine their effects on dose estimates.
1.5 Method for Evaluating Uncertainty 1.5.1 *Is the method deterministic or probabilistic and what kind of uncertainty or sensitivity analysis is used?*	Typically, the models are deterministic, with a set of parameters used as input and producing a resulting output value. In reality input parameters are not single values; they exhibit stochastic variability. There is uncertainty in the input data used in a model; therefore, there is uncertainty in the output estimated by the model. Therefore, the method is probabilistic. A quantitative uncertainty analysis was performed using a variety of techniques, depending on the individual analysis. The techniques used were (1) assigning generic estimates of uncertainty to the results based on similar published analyses, (2) performing simple parameter perturbation analyses, or (3) performing Monte Carlo analyses. Various techniques were also used to estimate sensitivity, such as (1) generic estimates using published sensitivity analyses, (2) simple perturbation analyses, or (3) correlation coefficients calculated from Monte Carlo analyses.	The sensitivity analysis is approached deterministically by evaluating the change in the estimate as a function of systematic changes in the parameter value (page 4-7). Uncertainty in estimates are evaluated deterministically by considering likely ranges of values for parameters used in the required calculation (page 4-12).
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process?*	Not applicable	Not applicable

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
1.6.2 *Does the code approval process include validation and/or verification?*	The INEL PA contains Appendix D which contains a description of the computer codes used in the Radioactive Waste Management Complex (RWMC) PA. This description includes information about verification and validation of the codes. The codes used in the RWMC PA are: MICROSHIELD 4, GENII, GWSCREEN, PORFLOW, ORIGEN2, AND RESRAD.	Testing of the VAM3D-CG computer code, Version 2.4b, was conducted to establish confidence that the code was ready for use in performance assessment applications at the Hanford site. Verification and benchmarking were used to check the capabilities and limitations of the code to simulate diverse hydrological and geological conditions pertinent to PA applications (see Appendix G2). The primary method for completing dose calculations was a set of hand calculations on a spreadsheet. Radionuclide concentration inventory limits were derived from these calculations. The computer code GENII, Version 1.485, was used for benchmarking purposes, to compare results and to ensure accuracy of the spreadsheet formulas and calculations. The spreadsheet formulas are discussed in Appendix C of the PA (page 3-3).
1.6.3 *Is there a list of pre-approved codes?*	Not applicable	Not applicable
2. Receptor (most exposed individual) 2.1 Receptor Scenario 2.1.1 *What general assumptions are required?*	Not applicable	Not applicable

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
2.1.2 *What site-specific assumptions are used?*	Assumptions are made that the operational period of the RWMC will end in the yr 2020, the institutional control period will last for 100 yr and during that period the facility will be closed, stabilized, and maintained but will still be fenced and patrolled and be part of the INEL reservation. Closure will consist of a thick soil barrier, which includes a vegetative cover that is placed over the operational cover. The total thickness of the cover at closure is 5 m. During the post-institutional period, after yr 2120, the facility is no longer maintained by the DOE and may be accessible to the public. During this time no maintenance is performed on the cover and erosion is assumed to occur down to the existing RWMC grade. At the time of maximum erosion, this results in 2.4 m of cover remaining over the waste in the pits and 3.3 m of cover remaining over the soil vaults. It is assumed that during the operational and institutional control periods the soil contamination levels will not be higher than current levels. Since studies show that none of the existing burrowing animals at the INEL have been observed to burrow deep enough to penetrate the waste, it is assumed that harvester ants, which have been found in Wyoming and at the Hanford site, will appear at the INEL and burrow into the waste. It is also assumed that the deep roots of the big sagebrush penetrates the waste to bring radioactivity to the surface. The total activity brought to the surface through plant uptake is assumed to be dispersed into the environment and blown to a hypothetical receptor. This assumes that the entire big sagebrush aboveground biomass is converted to a dispersible form. There are also assumed scenarios for the most exposed member of the public and the hypothetical inadvertent intruder.	The PA evaluated disposal facilities for Category 1 and Category 3 waste. These wastes are similar, although not identical, in radionuclide content to the NRC defined Class A and Class C wastes. It is assumed that the Category 1 waste facility will be covered with a minimal thickness of cover of about 3 m and the Category 3 facility will be covered with a minimum thickness of 5 m. The covers will be designed to limit or prevent erosion unless disturbed by man. Category 3 waste will be stabilized to support the soil cover overburden (page 2-35). The Category 1 facility is assumed to have a recharge rate (infiltration of rainwater into the soil column) of 5 cm/yr and the Category 3 facility is assumed to have a recharge rate of 0.5 cm/yr (page 3-17).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
2.1.3 *Are variations used to model against possible future environmental conditions?*	The possibility of flooding occurring at the RWMC is discussed and evaluated in the Uncertainty and Sensitivity Analysis section of the PA. Flooding is also mentioned as an area where additional studies are needed.	At the Hanford site, the meteorological conditions that require consideration are precipitation, flooding potential, high winds, and tornados. Of these the most important process relative to PA analyses is the assumption of recharge rates resulting from precipitation. A range of recharge rates is considered in the PA analysis as a function of assumed conditions (page 2-16). The processes of flooding, tornados, and high winds are not evaluated in the PA analysis. A short discussion of the reasons for not considering these conditions appears in Chapter 2 (page 2-17). The prevalent use of well water in the area for agricultural purposes (drinking and irrigation) requires that well drilling and water use for drinking and farming be considered as a primary means of exposure. The assumption of well drilling is used in the development of inadvertent intruder scenarios and all-pathways scenarios. The effects of large-scale commercial irrigation on site are also considered as a sensitivity case (page 2-19).
2.2 Dose Standard 2.2.1 *What is the dose standard (performance objective) for the most exposed individual?*	The dose standards used for the RWMC PA are: For the public, the annual dose is 25 mrem EDE per DOE 5820.2A. For the inadvertent intruder the annual EDE for chronic exposure is 100 mrem and the dose for an acute exposure is 500 mrem EDE per DOE 5820.2A. For the public the annual dose from air emissions is 10 mrem EDE per 40 CFR 61. For the public the annual dose from a community drinking water system is <4 mrem EDE and the drinking water gross alpha emitter concentration shall be less than 15 pCi/L (including Ra-226; excluding uranium and radon) and the radium-226 and -228 total concentration shall be less than 5 pCi/L, per IDAPA 16.01.08000, and 40 CFR 141.	At the Hanford site, the U.S. DOE, Richland Operations Office has generated a supplemental Order, DOE-RLID 5820.2A that provides the following additional or clarifying performance objectives for the most exposed member of the public (page 1-5): General Public Protection. Disposal systems shall be designed to ensure that exposure to any member of the public that results from disposal of solid LLW shall not exceed 25 mrem/yr EDE through all exposure pathways for at least 1,000 yr after disposal. The point of compliance shall be no further from the edge of the waste than the Hanford site boundary during the period of active institutional control. After the active institutional control period (assumed to be not more than 100 yr), the point of compliance shall be not more than 100 m from the edge of the disposal site. Groundwater Protection. Disposal systems shall be designed to ensure that disposal of LLW after September 26, 1988, does not result in concentrations of radionuclides (above existing levels) in groundwater exceeding those corresponding to an EDE of 4 mrem/yr to any person who might drink 2L/d of water from a well drilled into the aquifer, for at least 1,000 yr after disposal. The point of compliance shall be no further than 100 m from the edge of the waste.

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
2.3 Point of Compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	During the operational and institutional control period, the member of the public resided at the INEL site boundary. During the post-institutional control period, the member of the public resided 100 m from the RWMC SDA boundary. The intruder was assumed to inadvertently intrude onto the RWMC SDA during the post-institutional control period. The intruder scenarios provide more details about the way that the intruder picks up the dose of radioactivity.	The point of compliance for protection of the general public shall be no further from the edge of the waste than the Hanford site boundary during the period of active institutional control. After the active institutional control period (assumed to be not more than 100 yr), the point of compliance shall be not more than 100 m from the edge of the disposal site. The point of compliance for groundwater protection shall be a well that is drilled no further than 100 m from the edge of the waste.
2.4 Time of Compliance 2.4.1 *What is the time of compliance (time certain or peak dose)?*	The operational period was assumed to last from 1984 to 2020, at which time the RWMC was assumed to be closed. The period of institutional control was assumed to last for 100 yr, 2021 through 2120, during which time maintenance and surveillance monitoring of the RWMC continued and no additional waste was received. During this time, the INEL site boundary was maintained, restricting public access to the RWMC. The post-institutional control period, beginning in the year 2120, is the period during which no maintenance or surveillance monitoring occurred, and the area was available for unrestricted access and use by the public. The period has an indefinite ending point; analyses were made out to the point of maximum potential impact.	For the drinking water pathway, a minimum time of compliance of 1,000 yr post closure has been specified in DOE-RL Order 5820.2A. As a design goal, the time of compliance has been extended to 10,000 yr for potential doses received from the drinking water, all-pathways, and Columbia river scenarios. The analyses generally show that the peak doses occur at times less than 10,000 yr (e.g., about 1,000 yr or less). In cases where peak doses occur after 10,000 yr, the results and their impacts are discussed (page 1-8).
2.4.2 *What assumptions are made about future land ownership/control?*	Because of the limitations of the land, it is not probable that a community would be established in the future at the RWMC. It is more likely that the area could be used for grazing livestock, such as cattle or sheep, and a well could be used for watering stock. The scenarios used in the PA calculations are unlikely cases.	It is assumed that a person could live, farm the land, drill a well, and raise livestock 100 m down gradient from the disposal facility after the end of the institutional control period (page 3-30).
2.4.3 *What institutional control period is specified?*	The period of institutional control was assumed to last for 100 yr, 2021 through 2120, during which time maintenance and surveillance monitoring of the RWMC continued and no additional waste was received. During this time, the INEL site boundary was maintained, restricting public access to the RWMC.	The institutional control period is assumed to last for 100 yr postclosure (page 1-8).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
2.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	Assumptions are made that the operational period of the RWMC will end in the year 2020, the institutional control period will last for 100 yr and during that period the facility will be closed, stabilized, and maintained but will still be fenced and patrolled and be part of the INEL reservation. Closure will consist of a thick soil barrier, which includes a vegetative cover that is placed over the operational cover. The total thickness of the cover at closure is 5 m. During the post-institutional period, after year 2120, the facility is no longer maintained by the DOE and may be accessible to the public. During this time no maintenance is performed on the cover and erosion is assumed to occur down to the existing RWMC grade. At the time of maximum erosion, this results in 2.4 m of cover remaining over the waste in the pits and 3.3 m of cover remaining over the soil vaults. It is assumed that during the operational and institutional control periods the soil contamination levels will not be higher than current levels. Since studies show that none of the existing burrowing animals at the INEL have been observed to burrow deep enough to penetrate the waste, it is assumed that harvester ants, which have been found in Wyoming and at the Hanford site, will appear at the INEL and burrow into the waste. It is also assumed that the deep roots of the big sagebrush penetrates the waste to bring radioactivity to the surface. The total activity brought to the surface through plant uptake is assumed to be dispersed into the environment and blown to a hypothetical receptor. This assumes that the entire big sagebrush aboveground biomass is converted to a dispersible form. There are also assumed scenarios for the most exposed member of the public and the hypothetical inadvertent intruder.	Category 1 waste is assumed to be covered by a minimal thickness of cover (about 3 m), thus allowing the exhumation of waste by the inadvertent intruder who digs a basement. The category 3 waste is assumed to be covered by a minimum 5 m cover. It is assumed that a cover will be designed to limit or prevent erosion unless disturbed by humans (page 2-35).
2.5 Dose Conversion 2.5.1 *What requirements or standards are used to determine dose conversion factors?*	The GENII computer code (version 1.485) was used to model the doses resulting from RWMC releases. Doses due to inhalation, ground surfaces, air immersion, and ingestion were calculated. The output from GENII is the EDE, which included the 50-yr committed EDE from internal exposure through the ingestion and inhalation pathways and the external EDE from ground deposition and air immersion. The dose conversion factors used in this analysis are from the GENII library that uses the most conservative dose conversion factors contained in DOE/EH-0070[6] and DOE/EH-0071.[7]	The dose calculations were done by hand calculations on a spreadsheet and compared to computer code calculations using GENII, Version 1.485 (page 3-3). The PA contains a comparison Table that lists dose conversion factors from the GENII computer code, EPA-520 (RFG-11, 1988),[8] and DOE/EH-0071.[7] The DOE dose conversion factors were actually used in the calculations (page C-15).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
3. Receptor (inadvertent Intruder) 3.1 Receptor Scenario 3.1.1 *What general assumptions are required?*	Not applicable	Not applicable
3.1.2 *What site-specific assumptions are used?*	It is assumed that the intruder at the INEL would have to use ground water because there is no reliable source of surface water. The acute intruder-construction scenario was not evaluated for the soil vault rows because a basement excavation would not contact the waste. The contaminated drillings brought to the surface by the intruder in the acute intruder-drilling scenario are assumed to be spread over the ground instead of in a mud pit because that is the practice in the area. The cuttings were assumed to be spread over a 2,200 m^2 lot. It was assumed that the intruder drills and develops a 22-in. diameter irrigation well and is exposed to the contaminated cuttings for 160 hr. Leaching of the radioactivity from the waste was not incorporated into the intruder dose assessments. This has little impact over relatively short time periods, however, it is an extremely conservative assumption over very long time periods.	The PA assumes that wastes that remain hazardous to inadvertent intruders beyond 100 yr (Category 3 waste) will have passive controls, such as, long-term government ownership and control, appropriate markers, and barrier systems, incorporated to provide reasonable assurance that inadvertent intruders will be warned and deterred from disturbing the site for up to 500 yr (page 1-6). It is also assumed that Category 3 waste is buried at sufficient depth (5 m or more) to eliminate excavation and root penetration as a feasible means of exhuming waste (page 3-2). Additional assumptions about the inadvertent intruder scenarios appear on pages 3-5 and 3-6 of the PA.
3.1.3 *Are variations used to model against possible future environmental conditions?*	The recommended intruder scenarios to use are specified and some site-specific modifications are permitted if justified, therefore, it is not appropriate to assume a different intruder scenario that might occur during or after some potential major change in environmental conditions. One could always find some scenario where the intruder performance objectives would be exceeded. That is not the purpose of the performance assessment.	
3.2 Dose Standard 3.2.1 *What is the dose standard for the most exposed hypothetical inadvertent intruder?*	The dose standards for the inadvertent intruder are the same as the requirements.	The dose standards for the inadvertent intruder are the same as the requirements.
3.3 Point of Compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	The intruder is assumed to inadvertently intrude onto the RWMC SDA during the post-institutional control period. Intruder scenarios provide more detail about how the intruder is exposed to radioactivity.	For the intruder dose limits it is assumed that the intruder contacts the waste directly (page 1-7). The assumed acute exposure of the inadvertent intruder is during excavation of a home basement when waste is exhumed as part of construction, and when waste is exhumed while drilling a water well. The chronic exposure scenarios are post excavation and postdrilling, during which the exhumed waste is mixed with soil, spread around the site, and subsequently used to grow crops for consumption (page vii).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
3.4 Time of Compliance 3.4.1 *What is the time of compliance (time certain or peak dose)?*	The intruder calculations begin after the institutional control period ends, in the year 2120. This period has an indefinite ending point. Calculations were carried out to peak dose. The maximum dose to a hypothetical individual intruding into the pits occurred at approximately 1,000,000 yr.	Inadvertent intrusion occurs in the Category 1 waste at the end of the institutional control period, 100 yr. However, because of passive controls inadvertent intrusion occurs in Category 3 waste at 500 yr (pages viii and ix, and 1-8).
3.4.2 *What assumptions are made about future land ownership/control?*	It is assumed that at the end of the institutional control period there will be no control over anyone living anywhere on the site. Nothing is specified about ownership of the land. Therefore, calculations of doses to the intruder are made using the prescribed intruder scenarios with some site-specific modifications.	It is assumed that at the end of the institutional control period there will be no control over anyone living anywhere on the site. Nothing is specified about ownership of the land.
3.4.3 *What institutional control period is specified?*	The period of institutional control was assumed to last for 100 yr, 2021 through 2120, during which time maintenance and surveillance monitoring of the RWMC continued and no additional waste was received. During this time, the INEL site boundary was maintained, restricting public access to the RWMC.	The institutional control period is assumed to last for 100 yr postclosure (page 1-8).
3.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	During the post-institutional period, after year 2120, the facility is no longer maintained by the DOE and may be accessible to the public. During this time no maintenance is performed on the cover and erosion is assumed to occur down to the existing RWMC grade. At the time of maximum erosion, this results in 2.4 m of cover remaining over the waste in the pits and 3.3 m of cover remaining over the soil vaults.	Category 1 waste is assumed to be covered by a minimal thickness of cover (about 3 m), thus allowing the exhumation of waste by the inadvertent intruder who digs a basement. The category 3 waste is assumed to be covered by a minimum 5 m cover. It is assumed that a cover will be designed to limit or prevent erosion unless disturbed by humans (page 2-35).
3.5 Dose Conversion 3.5.1 *What requirements or standards are used to determine dose conversion factors?*	The GENII computer code (version 1.485) was used to model the doses resulting from RWMC releases. Doses due to inhalation, ground surfaces, air immersion, and ingestion were calculated. The output from GENII is the EDE, which included the 50-yr committed EDE from internal exposure through the ingestion and inhalation pathways and the external EDE from ground deposition and air immersion. The dose conversion factors used in this analysis are from the GENII library that uses the most conservative dose conversion factors contained in DOE/EH-0070[6] and DOE/EH-0071[7].	The dose calculations were done by hand calculations on a spreadsheet and compared to computer code calculations using GENII, Version 1.485 (page 3-3). The PA contains a comparison Table that lists dose conversion factors from the GENII computer code, EPA-520 (RFG-11, 1988)[8], and DOE/EH-0071[7]. The DOE dose conversion factors were actually used in the calculations (page C-15).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
4. Release Mechanism 4.1 Waste Inventory 4.1.1 *What are the requirements for keeping records on waste inventory?*	For materials to be shipped to the INEL receiving facilities, isotopes that are detected with a true-positive indication are reported. Isotopes below 0.1 pCi/g alpha and beta and less than 1.0 pCi/g gamma are not required to be reported. This reporting guidance is not to be misconstrued as a definition of non-radioactive or as unrestricted release limits.[12]	An annual report is prepared describing some of the characteristics of LLW being disposed at the Hanford site and projected to be disposed during the next 30 yr. Most of the information in this PA comes from the information in the annual reports dated 1992 and 1993. The reports describe the physical and chemical makeup of the waste and the volumes of waste expected to be disposed at the Hanford Site. The reports also discuss uncertainties in the volume estimates and the potential for additional sources of waste. Radionuclide inventory data are not provided in the annual report. Information on radionuclide inventory is summarized from responses to waste characterization questionnaires provided by the individual generators. Also, a computerized data base, the Solid Waste Information and Tracking System (SWITS), provides inventory and waste volume data on a container-by-container basis. These records are somewhat limited because a complete listing of specific radionuclides has not been required until the last 2 yr (this probably means 1992 and 1993 since the PA document is dated 1994). The PA covers the waste buried from 1989 through 1992 and the projected waste to be buried through the year 2021 (page 2-20).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
4.1.2 *How do current requirements for keeping records differ from past requirements?*	For waste shipments prior to 1960, there are no shipping records for the waste received from on the INEL. There are shipping records for waste received from the Rocky Flats Plant (RFP) in Colorado. Those records generally provide no quantitative information concerning the contaminants. The physical and chemical descriptions for the wastes disposed of between 1971 and 1986 do not provide insight into the actual contents of the waste (e.g., plant waste). The radionuclide information is very limited, such as: (a) entries with only one radionuclide identified, such as Pu-239, when knowledge of the waste generating process indicates that other radionuclides would also be present; (b) entries with only the element specified, e.g., uranium, with no designation of a particular radionuclide or mixture of radionuclides; entries with only generic radioactivity terms MAP or MFP identified, with no designation of particular radionuclides; and (d) entries with only one fission product or activation product identified, e.g., Cs-137 or Co-60, when others should also be present. Prior to 1986 the data stored were only on a shipment basis. The activity or mass identified for a particular isotope was only identified for an entire shipment and not for individual containers.[13]	Before 1970, no distinction was made between TRU and LLW. In 1970, the AEC required that TRU waste be retrievably stored. Types of underground retrievable storage included shallow trenches, concrete lined "V" trenches, and asphalt pads. The segregated LLW continued to be disposed of. In the early 1980s, low-level liquid organic waste was segregated from LLW and stored retrievably underground. A further categorization of LLW was made in 1987 when the concept of Mixed Waste (MW) was established. Mixed waste disposal was largely discontinued except on a case-by case basis where a significant reason for disposal could be justified. Storage on non-remote handled MW in above-ground buildings is the current practice (page 2-26).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory for purposes of the PA?*	The RWMC PA covers the period from 1984 through 2020. Unidentified activity accounts for only 0.12% of the activity disposed of in the pits and 0.033% of the activity disposed of in the soil vault rows. The activity is taken from the INEL data base RWMIS. Unidentified activity (denoted mixed activation products, mixed fission products, and unidentified beta-gamma) was assumed to be 50% Sr-90 and 50% Cs-137. The use of other radionuclides for unidentified activity was evaluated in the uncertainty analysis.	To address the intruder performance objectives a list of averaged radionuclide specific concentrations was determined using the four year record of radionuclide and generator specific waste disposed in the LLBG from 1989 through 1993 (Appendix B). A total projected inventory for the long-lived environmentally mobile radionuclides was estimated by extrapolating the 4-yr inventory to 30-yr (page 4-72). Because some uncertainties severely restricted Hanford's ability to predict a finite LLW inventory, they used a unique approach to analyze the performance of the 200 West Area Burial Grounds. Unit concentrations or quantities of radionuclides were assumed, depending on the type of analysis. Groups of radionuclides were categorized into sets of different chemical properties. The analyses were then completed for a limited number of characteristic properties, such as, four different distribution coefficient (K_d) values. The predicted dose under these conditions are then determined and compared with the appropriate performance objective dose limit. Because a unique dose corresponds to a unit concentration or quantity of a radionuclide if all other parameter are held constant, the concentration or quantity of a radionuclide can be calculated which corresponds to the dose limit. This allows calculation of inventory limits for any set of radionuclides. Also, different sets of inventory limits can be calculated for a variety of combinations of environmental and disposal conditions, some of which provide greater isolation capability than others. Thus, a means of disposing of a range of waste inventory concentrations and/or quantities is provided (page 2-24 and 2-25).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
4.2 Source Term 4.2.1 *What assumptions are made about the release of radionuclides from the various waste forms?*	Release of radionuclides from activated metals and waste containers were modeled. Release from activated metals was by corrosion leaching or by diffusion of tritium from beryllium blocks. The average release rate constant for corrosion release from activated carbon or stainless steel was calculated to be 4.17E-4/yr. The release rate constant for corrosion release of tritium from beryllium blocks was calculated to be 9.27E-4/yr. Corrosion release from the beryllium blocks was determined to be the dominate release mechanism for tritium. All tritium released from the blocks was assumed to partition into the soil pore water and migrate toward the aquifer.[10]	To introduce conservatism into the source term release estimates, the following assumptions were made: (1) It was assumed that containers were not present in the disposal facility and had no influence on the time at which waste would come in contact with infiltrating water. (2) For waste materials disposed directly without treatment, it was assumed that the radionuclide inventory in those wastes was immediately available for release into the infiltrating water solution. (3) It is assumed that all infiltrating water receives the maximum amount of dissolved radionuclides prescribed by the release mechanism assumed in the modeling analysis. (4) For those wastes that are incorporated into a waste form that controls radionuclide release by diffusion or sorption or solubility mechanisms, such as grout, it is assumed in the models that the diffusion coefficient values remain constant over time.
	The release rate constant for waste contained in metal containers was estimated to be 0.1 per year and the release rate constant for waste in containers other than metal was assumed to be 0.5 per year. At an infiltration rate of 7 cm/yr the result is a relatively instantaneous release of radionuclides from nonmetal containers following disposal.[12]	In addition, the radionuclide inventories are assumed to be homogeneously distributed among the waste (page 3-11). An advection-dominated release model (mixing-cell cascade model) is used to simulate the processes of releases from unstabilized waste. A diffusion-dominated release model is used to simulate the release of contaminants from stabilized wastes. In addition to the diffusion-dominated release of the radionuclides from the burial trench, an alternative approach is to specify a solubility limit in the waste form (pages 3-12 to 3-15). For source term release, the mass transfer code VAM3D-CG is used to quantify the groundwater advective flux conditions and an analytical solution, and the mixing-cell cascade model[14] is used to calculate the radionuclide release from the waste material or waste form (page 3-8).
4.2.2 *For purposes of the PA during operations or for closure, is all waste included in the source term?*	The RWMC PA covers the period from 1984 through 2020. The environmental restoration program at the INEL will assess waste buried in the SDA from 1952 through 1983 in accordance with the National Contingency Plan under CERCLA.	The total inventory for the 200 West Area LLBG was determine by using the LLBG inventory records for 1989 to 1992 and combining those with 30-yr volume forecasts provided by the generators (page XI). The PA analysis does not consider radiological releases from transuranic wastes or LLW disposed before September 1988. Wastes disposed before September 26, 1988 will be the focus of CERCLA remediation evaluations or RCRA closure (page 1-1).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
4.2.3 *What is the source of scaling factors for indirectly measured radionuclides?*	To convert MAP and MFP to specific radionuclides, it was assumed that radionuclides contained in spent nuclear fuel would be representative of MFP and radionuclides contained in fuel disassembly hardware and control rod elements would be representative of MAP. The specific radionuclides that were evaluated were derived from the Characteristics Data Base (CDB) developed by Oak Ridge National Laboratory in 1987.[15]	There is no mention of use of scaling factors to determine any of the radionuclides in the waste inventory. The Tables in Appendix B appear to cover the difficult to analyze radionuclides such as C-14, Tc-99, and I-129.
5. Pathways 5.1 Site Characteristics 5.1.1 *Must data about site characteristics meet any quality requirements in order to be used in the PA?*	The PA results are based on assumptions, simplifications, and scenarios that, in most cases, erred on the side of conservatism. Any uncertainties in the results due to a lack of a QA/QC program for data on site characteristics is expected to be minor compared to the assumptions, simplifications, etc. that were used.	There is no information in this PA about the quality requirements for the data on site characteristics.
5.1.2 *What requirements are there to avoid the potential for "masking" from nearby nuclear facilities?*	The environmental monitoring program at the INEL is the primary mechanism to determine RWMC compliance with the applicable performance objectives. Results of the environmental monitoring program are analyzed for potential problems so corrective actions to waste disposal methods at the RWMC can be taken if needed.	In the area of the 200 West Area LLBG there are three other current or planned LLW disposal sites. The 200 East Area disposal site is east of the 200 West Area site. The U.S. Ecology site is located southwest of the 200 East Area site and the ERDF site is located west of the U.S. Ecology site. The groundwater flow is generally from west to east in this area. A two page discussion on the dose effects from the mixing of the contaminant plumes from these sites is given in the PA document (pages 4-60 through 4-63). The conclusion is that a relative increase in groundwater contamination due to the interaction of plumes from the 200 West Area Burial Grounds and other plumes on site is not expected.
5.2 Waste Distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to the most exposed individual?*	All soil vault inventory and pit inventory was assumed to be placed in a composite active disposal pit. The "composite" pit was assumed to have the combined dimensions of the pits used for disposal from 1984 through 1993 and forecast to be used for disposal from 1994 to 2020. All waste was assumed to be homogeneously mixed in the active pit volume.[12]	Radionuclide inventories are assumed to be homogeneously distributed among the wastes (page 3-11).

Table D-3. (continued).

Parameter	INEL (RWMC)	Hanford (200 West Area)
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to a hypothetical inadvertent intruder?*	The distribution of waste for calculating the dose to the hypothetical inadvertent intruder is the same as the distribution of waste for calculating dose to the most exposed individual (see paragraph PA.5.2.3.1 above).	In the inadvertent intruder scenarios the waste is extracted directly from the disposal facility. The exhumed waste is assumed to be indistinguishable from soil with the exception of activated metal. It was assumed that radionuclides entrained in activated metal are less likely to be dispersed into the environment even when exhumed and mixed with soil, thus reducing the potential dose from this source relative to other waste materials (page 3-1).

Table D-4. DOE Performance Assessment Practices for ORNL (SWSA 6) and Savannah River Site (E-Area Vaults).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
1. General 1.1 Format and Content 1.1.1 *What is the general format and contents of the PA?*	The PA[16] has been prepared in accordance with the guidance provided by the DOE Peer Review Panel that outlines the format and content for a radiological performance assessment[2] (page xxi).	The format and content of the PA[19] generally follow DOE/LLW-81,[2] with some modifications to Sections 2, 3, and 4.
1.2 Approval Process 1.2.1 *What is the formal process for final approval of the PA?*	Not applicable	Not applicable
1.3 Review Process 1.3.1 *What formal review process does the PA go through before submittal for approval?*	Not applicable	Not applicable
1.4 PA Maintenance 1.4.1*Does the PA need to be reviewed and updated if parameters change?*	Results of continued work on the PA[16] to address several elements and the changes in operations will be incorporated into a revision of the PA for SWSA 6 (page xxv).	The PA[19] is to be maintained through time, and thus is a living document. Further iterations of the PA process will benefit greatly if opportunities are identified that will decrease the conservatism in the analysis. Reducing conservatism in the PA should enable disposal limits to be increased, thus enhancing the utility of the E-Area vaults. Opportunities to reduce the conservatisms are discussed on pages 5-3 and 5-4.
1.5 Method for Evaluating Uncertainty 1.5.1 *Is the method deterministic or probabilistic and what kind of uncertainty or sensitivity analysis is used?*	Deterministic and probabilistic methods were used to calculate the most probable, maximum, and minimum estimates of activity in wastes. The most probable or best estimates were used in the analysis and are presented with the 95% confidence level maximum and minimum activity values in Appendix A. The uncertainty in the inventory data in the analysis of environmental transport is addressed in Subsections of Section 4.6. The Latin Hypercube (LHC) sampling method was used to analyze the effects of input variable uncertainties on the simulation models used in this study. LHC sampling[17] has been shown to require fewer model iterations to approximate the desired variable distribution than the simple Monte Carlo method. PRISM[18] was the program used to implement the LHC sampling technique for sensitivity and uncertainties analyses of the model predictions. A statistical summary of the model results produced indices of sensitivity and uncertainty that related the effects of heterogeneity of input variables to model predictions (page 4-69 to 4-70).	A rigorous quantitative analysis of uncertainty is desirable, but such an analysis is not possible for all aspects of the analyses conducted for the PA due to: (a) limits of our knowledge with respect to certain physical and functional characteristics or processes; (b) the ability to predict conditions in the future, especially beyond several decades; and (c) the inability to quantify uncertainty associated with the definition of a particular scenario. This last type of uncertainty can dominate the overall uncertainty in some cases (page 4-81). Further discussion of the sensitivity and uncertainty analysis is covered on pages 4-81 to 4-90.

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process?*	Not applicable	Not applicable
1.6.2 *Does the code approval process include validation and/or verification?*	Simulations of the release of radionuclides from disposal units and subsequent transport in water were carried out using the following six computer codes (page 3-33): 1. UTM - used to model the site water budget (US DOE code center approved) 2. SOURCE1 - models the performance of the tumulus disposal technology 3. SOURCE2 - models the performance of disposal silos, wells, multiple containment wells, and biological trenches 4. WELSIM - simulates shallow subsurface transport and nuclide flux to groundwater from wells, silos, and trenches 5. TUMSIM - describes lateral subsurface nuclide transport through the stormflow zone and transport to groundwater through recharge from tumulus disposal units 6. USGS MOC - models solute transport and dispersion in a saturated porous medium (US DOE code center approved) The status of the verification and validation of these codes is discussed on pages 3-38 through 3-41. The verification and validation efforts at the time of the report were not complete, however, the authors feel that these codes have been verified and validated to a reasonable extent for use in the PA.	Appendix B of the PA contains a list of code selection criteria and considerations. One of the criteria that was an absolute requirement for selection of a code was, "The selected code(s) should be verified (i.e., simulation results compared against known analytical solutions of the underlying equations) to demonstrate correctness of the source code. Such verification should be fully documented in a technical report made available, at a minimum, to SRS and the Peer Review Panel." Another criteria that was an absolute requirement for selection of a code was, "All simulation codes selected for use in the PA must be maintained under a software QA and management program that assures that modifications and updates are traceable, auditable and documented, and that all production versions have been verified and validated." Other criteria that was desirable, but not required for selection of a computer code was, "The code(s) should be validated (e.g., simulation results compared with field data) for a system similar to that being modeled whenever possible. Benchmarking (i.e., code-to-code comparisons) is also useful in demonstrating code capabilities."
1.6.3 *Is there a list of pre-approved codes?*	Not applicable	Not applicable
2. Receptor (most exposed individual 2.1 Receptor Scenario 2.1.1 *What general assumptions are required?*	Not applicable	Not applicable

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
2.1.2 *What site-specific assumptions are used?*	There are a variety of disposal methods used for LLW at SWSA 6. Biological wastes were disposed of in a trench and covered with at least 3 feet of dirt. When the trench was filled, the surface of the closed trench was planted with grass, mowed and kept free of trees. Biological waste is no longer disposed if in the SWSA 6 trenches. The current plan is to incinerate this waste and store or dispose in a tumulus facility (page 2-50). The remaining wastes disposed of at SWSA 6 are closed with concrete covers. Diffusion of contaminants through concrete is assumed to be the primary mechanism of release during the period of time that the concrete remains intact. Observations at ORNL over the last few decades suggest that emission of radionuclides directly to the atmosphere in gaseous form is not an important release mechanism at the site (page 3-10). Releases of radionuclides from the disposal units to surface water and groundwater are assumed to be the primary pathways for the transport of radionuclides to the environment (page 3-10). An off-site individual is assumed to be exposed to contaminated surface water released into the Clinch River from the present location of the White Oak Dam. The maximally exposed individual is assumed to use the contaminated water for domestic and recreational purposes (page 3-19). Closure scenario assumptions are covered on pages 3-16 to 3-19. The operational period is assumed to end in 1997 and the institutional control period is assumed to end in 2097. During the post-institutional control period the maximally exposed individual is assumed to be beyond the site boundary near the location of the White Oak Dam. It is assumed that White Oak Lake will be drained prior to loss of institutional control (page 3-20). The presence of concrete barriers in all disposal units except the biological trenches is assumed to preclude the agriculture scenario for 300 years after disposal because normal excavation procedures used in digging a foundation for a home cannot readily penetrate an intact concrete barrier. For disposal in unlined biological trenches, the agriculture scenario is assumed to occur after 100 years (pages 3-23 and 3-24). The construction and drilling scenarios were not included in the dose analysis for inadvertent intruders (page 3-25). The consumption rate of contaminated drinking water by exposed individuals was assumed to be 2L/day and an exposure time for the discovery scenario was	The E-Area Vaults (EAV) have been designed to handle LLW that is classified as low-activity waste (LAW), intermediate-activity waste (IAW) and tritiated waste. IAW consists of material that radiates greater than 200 mR/hr from an unshielded container at 5 cm. LAW consists of material that radiates less than 200 mR/hr from an unshielded container at 5 cm. Tritiated waste is waste that contains greater than 10 Ci of tritium per container regardless of the radiation rate. The EAV will not dispose of or store liquid wastes, waste containing greater than 100 nCi/g of TRU isotopes, hazardous waste, or mixed waste (page 1-4). Following are some assumptions used in this PA. This is not intended to be a complete list of assumptions, only a sample. The cover remains functional until the roof of the vault fails (page 3-6 and 3-57). The screening calculations assumed that the receptor consumes 2 L/d of the pore fluid that would be present if the radionuclides were deposited directly in the groundwater (page 3-55). Contaminants escaping the vault cannot diffuse upwards through the cover. Advection dominates transport outside the vault (page 3-57). For the LAW vault, it is assumed that the containers have completely degraded and collapsed at the start of the simulation, yielding a large void above the waste (page 3-57). It is assumed that the flow around the intermediate-level vault is at a steady state for the entire time that the vault is assumed to remain intact (page 3-61). Geochemical properties for the waste form are assumed to persist for the duration of the simulation (page 3-70). Fractures occur at regular intervals as determined by the structural calculations; all fractures open simultaneously at a time specified; are assumed to be continuous and open, and filling or plugging by soils or precipitates is not considered; are saturated with water; and water drains freely at the base of the fracture (page 3-74). The recharge rate will remain constant during the future time period that is simulated; therefore, a steady-state flow will prevail (page 3-76). The compliance point is assumed to be the point of maximum concentration in groundwater, at least 100 m from the edge of the facility (page 4-17). It is assumed that offsite releases of volatile radionuclides (i.e., H-3 and C-14) can be neglected in the dose analysis beyond the buffer zone (page 4-28). It is assumed that the concrete is at a relatively low pH (at most 9.5) (page K-20). Since the EA Vault concrete has no calcium

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
(2.1.2 continued)	assumed to be about 100 hours (page 4-40). More assumptions are discussed on pages 3-26 to 3-31 and on page 4-42.	hydroxide available for leaching, the concrete strength is assumed to remain constant throughout the simulation (page K-24).
2.1.3 *Are variations used to model against possible future environmental conditions?*	There was no mention of possible long-term changes that may significantly impact the isolation capability of the disposal units at SWSA 6 that are covered in this PA. However, results of this PA shows that SWSA 6 does not presently meet the performance objectives of DOE 5820.2A.	Possible future environmental conditions that may affect degradation of the cover are: erosion, penetration by plants and animals; external events such as settling or slumping, or a seismic event; and human intrusion (page 3-5). Discussion of potential seismic events is found on pages 2-13 to 2-16. A detailed analysis of cover degradation is given in Appendix K.
2.2 Dose Standard 2.2.1 *What is the dose standard (performance objective) for the most exposed individual?*	The performance objectives that are used by the PA to demonstrate that LLW disposal methods meet the requirements of the US DOE are the same as those in DOE 5820.2A.	In addition to meeting the performance objectives in DOE 5820.2A, the PA for the EAV specifies the performance objective for protection of groundwater resources as, "Current EPA standards for radionuclides in drinking water, including the method prescribed by the EPA for calculating maximum contamination levels (MCLs) for beta/gamma-emitting radionuclides based on internal dosimetry data from ICRP Publication 2 (1959) and the specified MCLs for H-3 and Sr-90." (page 1-10) Compliance for radon will be assessed versus the radon exhalation rate that is stated as, "the limit for radon exhalation rate from the ground surface to air will be 20 pCi/m^{2}s (0.7 Bq/m^{2}s)." (Pages 1-11 and 1-12). Results from intrusion scenarios are presented to include doses from radon and its decay products; however, compliance is assessed by excluding the dose from radon and its decay products.
2.3 Point of Compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	During the operational and institutional control periods an off-site individual is assumed to be exposed to contaminated surface water released into the Clinch River from the present location of White Oak Dam. The maximally exposed off-site individual is assumed to use contaminated water released into the Clinch River from White Oak Creek for domestic and recreational purposes (page 3-19). During the post-institutional control period the maximally exposed individuals are also assumed to exposed to contamination near the location of the White Oak Dam (page 3-20).	The point of compliance for groundwater protection requirements is taken to be that location more than 100 m from any disposed water at which the predicted concentrations of contaminants in groundwater are the highest. Requirements for protection of groundwater do not apply inside a 100-m buffer zone around the disposal units (page 1-6).

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
2.4 Time of Compliance 2.4.1 *What is the time of compliance (time certain or peak dose)?*	The analyses for every radionuclide that was considered in detail was carried out to the point of peak dose. Peak doses for uranium isotopes included the effects of buildup of decay products at extraordinary long times (page I-2).	The performance objectives for protection of offsite members of the public, inadvertent intruders, and groundwater resources are applied for 10,000 years after disposal. If calculated doses to offsite members of the public or inadvertent intruders or calculated contaminant levels in groundwater do not attain their maximum values during the 10,000-year compliance period, the calculations are continued in time until the peak values are obtained (page 1-7).
2.4.2 *What assumptions are made about future land ownership/control?*	After the loss of institutional control it is assumed that an inadvertent intruder can establish a permanent homestead directly above the waste. However, the maximally exposed individual that lived off-site during the institutional control period is still assumed to be located beyond the site boundary near the location of the White Oak Dam during the post-institutional control period (page 3-20).	After the loss of institutional control, it is assumed that the maximally exposed offsite members of the public can be located as close as 100 m from any of the EAV. However, an inadvertent intruder can establish a permanent homestead directly above the waste.
2.4.3 *What institutional control period is specified?*	The institutional control period is assumed to last for 100 years post closure.	The institutional control period is the 100-year interval, specified in DOE 5820.2A, following closure of a disposal site (page 3-11).
2.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	During the institutional control period the waste is covered by an "exposed geomembrane cover" for 30 years that is assumed to provide 99% hydrologic isolation for the disposal units. A multilayer CERCLA cap is assumed to be placed over the tumulus units, IWMF, and other disposal units 30 years post closure and it is expected to last for 70 years. A scenario of gradual deterioration of the CERCLA cap is described for the 70 year period. Concrete covers are assumed to remain intact for at least 300 years post closure so that an intruder can not excavate through the concrete to the waste for building a house. After the 100 years of institutional control is ended the site is assumed to revert to forest vegetation through species succession after the grass cover is no longer maintained (pages 3-16 through 3-21).	The intermediate level (IL) vaults are adjacently located and are to be closed as one facility. The LAW vault facility will be closed separately. Closure of the vaults will be via below ground burial under about 8 feet of soil cover. The roof and walls of each vault type are expected to fail and collapse over time. This will result in infiltrating groundwater entering the interior of the vault rather than being diverted around its exterior (Appendix K, page 1). The waste in the IL vaults is to be grouted in place or enclosed in concrete until its failure (page 3-67). A vault degradation study estimates that the IL faults will remain intact for 575 years, cracks will be forming from 575 years to 1050 years, and they will fail at 1050 years or later. The same study estimates that the LAW vaults will remain intact for 1400 years, cracks will be forming from 1400 years to 3100 years, and they will fail at 3100 years or later (page 3-73).
2.5 Dose Conversion 2.5.1 *What requirements or standards are used to determine dose conversion factors?*	The internal dose conversion factors for ingestion and inhalation of radionuclides are from DOE/EH-0071[7] and the external dose conversion factors are from DOE/EH-0070[6]. Tables containing the dose conversion factors used in this PA are shown and discussed in Appendix G (pages G-6 to G-12).	The internal dose conversion factors for ingestion and inhalation of radionuclides are from DOE/EH-0071.[7] The external dose conversion factors with no shielding are from EPA 402-R-93-081[20] and the external dose conversion factors through the engineered barriers (45-cm shielding for the LAW vaults and 100-cm shielding for the IL vaults) are from Kocher and Sjoreen, 1985[21] (Appendix A, pages A-39 to A-62).

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
3. Receptor (inadvertent Intruder) 3.1 Receptor Scenario 3.1.1 *What general assumptions are required?*	Not applicable	Not applicable
3.1.2 *What site-specific assumptions are used?*	The parameter values used in the models for the different exposure pathways were usually intended to represent average conditions that might be experienced by off-site individuals or inadvertent intruders, as opposed to the maximum possible conditions that would yield the highest estimates of dose. Two exceptions to this are (1) the assumed consumption rate of contaminated drinking water by exposed individuals of 2 L/day, and (2) the assumption of an exposure time for the discovery scenario of about 100 hours. Both of these assumptions probably tend to overestimate exposure conditions that would be experienced by average individuals in critical population groups (page 3-10). Observations at ORNL over the last few decades suggest that emission of radionuclides directly to the atmosphere in gaseous form is not an important release mechanism at the site (page 3-10). Releases of radionuclides from the disposal units to surface water and groundwater are assumed to be the primary pathways for the transport of radionuclides to the environment (page 3-10). The presence of concrete barriers in all disposal units except the biological trenches is assumed to preclude the agriculture scenario for 300 years after disposal because normal excavation procedures used in digging a foundation for a home cannot readily penetrate an intact concrete barrier. For disposal in unlined biological trenches, the agriculture scenario is assumed to occur after 100 years (pages 3-23 and 3-24). The construction and drilling scenarios were not included in the dose analysis for inadvertent intruders (page 3-25).	Acute exposure scenarios for inadvertent intruders were not included because they would always be less restrictive in regard to demonstrating compliance with performance objectives than chronic exposure scenarios. Four chronic exposure scenarios were evaluated. A study showed that the vaults will be effective intruder barriers for at least 1,000 years. Doses from buildup of radium and radon daughters from U-238 and U-234 exceed performance objectives at very long times (200,000 to 2,000,000 years) after disposal. However, this PA assumes that only doses calculated out 10,000 years after disposal are considered for compliance. Also doses from radon and its decay products are excluded from inadvertent intruder dose for the purpose of assessing compliance (page 4092). A separate performance objective for radon (20 pCi/m^2s) was established. A conservative analysis for radon flux at 10,000 years showed that it met that performance objective (pages A-34 to A-36).
3.1.3 *Are variations used to model against possible future environmental conditions?*	See the comment from Table D-3 on this same question.	
3.2 Dose Standard 3.2.1 *What is the dose standard for the most exposed hypothetical inadvertent intruder?*	The dose standards for the inadvertent intruder are the same as the requirements.	The dose standards for the inadvertent intruder are the same as the requirements except the intruder dose does not include the dose from radon in the evaluation of compliance.

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
3.3 Point of Compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	The following four scenarios are assumed in the dose analysis for inadvertent intruders into the different disposal units at SWSA 6: an agriculture scenario involving direct intrusion into disposal units by excavation at anytime beyond 300 years after disposal for units constructed with engineered barriers and at anytime beyond 100 years after disposal for the biological trenches; a resident scenario involving exposure during residence in a home on top of intact engineered barriers above disposal units at 100 years after disposal (except for the biological trenches); a discovery scenario involving exposure while excavating at a disposal site in the presence of intact engineered barriers at 100 years after disposal for all disposal units except for the biological trenches (this is only applied to disposal units where the thickness of the engineered barriers at the sides of the units is considerably less than the thickness at the top of the units); a post-drilling scenario involving direct intrusion into disposal units by drilling at 100 years after disposal for all disposal units (page 3-24 and 3-25).	The intruder scenarios all assume that the intruder is located directly above the waste and in some scenarios is able to make direct contact with the waste.
3.4 Time of Compliance 3.4.1 *What is the time of compliance (time certain or peak dose)?*	The calculations are carried out to the point of peak dose for every radionuclide that was considered in detail Appendix I, page I-2).	The performance objective is assumed to apply for 10,000 years after disposal (page 3-39). Calculations on some daughter products of long-lived radionuclides were carried out for very long periods of time; however, they were not used to determine compliance with the performance objectives.
3.4.2 *What assumptions are made about future land ownership/control?*	After the loss of institutional control it is assumed that an inadvertent intruder can establish a permanent homestead directly above the waste (page 3-20).	After the loss of institutional control, it is assumed that the maximally exposed offsite members of the public can be located as close as 100 m from any of the EAV. However, an inadvertent intruder can establish a permanent homestead directly above the waste.
3.4.3 *What institutional control period is specified?*	The institutional control period is assumed to last for 100 years post closure.	The institutional control period is the 100-year interval specified in DOE 5820.2A following closure of a disposal site (page 3-11).
3.4.4 *What assumptions are made about active and passive controls that may affect PA results?*	Concrete covers are assumed to remain intact for at least 300 years post closure so that an intruder can not excavate through the concrete to the waste for building a house. After the 100 years of institutional control is ended the site is assumed to revert to forest vegetation through species succession after the grass cover is no longer maintained (pages 3-16 through 3-21).	A vault degradation study estimates that the IL vaults will remain intact for 575 years, cracks will be forming from 575 years to 1050 years, and they will fail at 1050 years or later. The same study estimates that the LAW vaults will remain intact for 1400 years, cracks will be forming from 1400 years to 3100 years, and they will fail at 3100 years or later (page 3-73). It is assumed that the vaults will be effective intruder barriers for at least 1,000 years (page 4-92).

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
3.5 Dose Conversion 3.5.1 *What requirements or standards are used to determine dose conversion factors?*	The internal dose conversion factors for ingestion and inhalation of radionuclides are from DOE/EH-0071[7] and the external dose conversion factors are from DOE/EH-0070[6]. Tables containing the dose conversion factors used in this PA are shown and discussed in Appendix G (pages G-6 to G-12).	The internal dose conversion factors for ingestion and inhalation of radionuclides are from DOE/EH-0071.[7] The external dose conversion factors with no shielding are from EPA 402-R-93-081[20] and the external dose conversion factors through the engineered barriers (45-cm shielding for the LAW vaults and 100-cm shielding for the IL vaults) are from Kocher and Sjoreen, 1985[21] (Appendix A pages A-39 to A-62).
4. Release Mechanism 4.1 Waste Inventory 4.1.1 *What are the requirements for keeping records on waste inventory?*	Waste generators complete standard forms for each waste package that they generate. In completing these forms they (1) determine the activity of the package by estimation, calculation (6CEn), assay, etc.; (2) state the physical form of the packets within the package, such as 5-gal metal cans, small plastic bags, etc.; (3) state the instrument used to perform the survey, such as a portable ion chamber or in-cell probe; (4) state the dose rate measured for the packets within the package; (5) state the distance from the instrument to the packet; and (6) state the assumptions concerning the packet contents, such as the nuclides in the packets (page A-41).	The E-Area Vaults are a new LLW disposal facility located at the SRS. Since it is a new facility, this PA does not mention anything about keeping records on the waste inventory.

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
4.1.2 *How do current requirements for keeping records differ from past requirements?*	For most facilities, operations personnel inferred the listed isotopes based upon their knowledge of the facility operation or the material being processed. In general, it cannot be said with certainty that any specific package contained the specific radionuclide(s) reported. It also cannot be stated that a package did not contain additional radionuclides other than those reported. On rare occasions, the waste was sampled and appropriate analyses were performed to specifically identify the radionuclides present. The identification of the principal isotope was straightforward for certain facilities that handled only specific isotopes and where the waste represented process waste. For many facilities, however, the waste form was contaminated components or irradiated materials that probably contained several different radionuclides. In these cases, the principal isotope identified in each waste package was the isotope or isotopes that were considered by the generator to be the most significant. The significance was typically based on an isotope's activity and radiological half-life. For example, irradiated metal waste, such as stainless-steel cladding hulls, contained a variety of activation products shortly after irradiation; but Co^{60} was reported as the only principal isotope because it was the most significant in terms of activity, half-life, and radiation energy. In other facilities the principal isotopes were listed as Cs^{137} and Sr^{90}. Operations personnel based this listing on the general operating history of the facility. Even though source production processes were operating in different hot cells, all packages of waste from the facility were considered to be composed of equal activities of Cs^{137} and Sr^{90} (page A-18). Additional information on the problems encountered in the determination of the quantity of the principal isotope are discussed on pages A-21 to A-26.	Not applicable since this is a new facility.

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory for purposes of the PA?*	For each radionuclide of interest in each disposal unit, the general methodology used to determine the total most probable activity and associated uncertainty involved a two-phased approach. The first phase consisted of evaluating the source inventory of each disposal unit and selecting records for a sufficient number of waste packages to comprise a relatively large percentage of the total activity for each radionuclide of interest. Interviews with waste generators and evaluation of data sheets for these significant packages were conducted. Based on the information gathered, the activity probability distribution was calculated and the most probable activity and associated minimum and maximum activity (at the 95% confidence interval) were determined for each radionuclide of interest in these significant packages. The second phase to the approach accounted for the remaining activity. The methodology used in the most probable activity calculation for the remaining activity was, in some cases, different than that used in the calculation for the significant packages. Once the proper method was selected, the assignment of uncertainties used to determine the minimum and maximum activity was identical to those used for the selected packages in phase one. The total activity for each radionuclide in the disposal unit is given by the sum of the most probable activities for the significant packages and the remaining activity. A similar summation gives the minimum and maximum activity for each radionuclide in each disposal unit (pages A-41 to A-43).	Not applicable
4.2 Source Term 4.2.1 *What assumptions are made about the release of radionuclides from the various waste forms?*	Leachate generated after water reaches the waste in the disposal units may be released through leaks in containment and by advection and diffusion through the concrete in the disposal units. In this PA, diffusion of contaminants through concrete is assumed to be the primary mechanism of release during the period of time that the concrete remains intact. When the concrete degrades and cracks are assumed to form, advection becomes the primary mechanism for release of radionuclides (page 3-10). Release of radionuclides from the above-ground (tumulus) disposal units is assumed to occur primarily to surface water or to the soil surface. Radionuclides released from the below-ground silos and wells are assumed to enter soils and groundwater. Releases of radionuclides from the biological trenches also occur mostly to groundwater and soils (page 3-13).	The waste is considered to be immobile until it contacts water. The entire inventory of the vault is assumed to be available to react with the water inside the vault. The aqueous concentrations of radionuclides are controlled by sorption onto corrosion products or grout with a solubility limited upper concentration. Contaminated water exiting the vault will interact with the concrete vault, and radionuclides will be chemically retarded by the vault wall (page 3-4). The release of radionuclides from the vaults depends on the vault aqueous chemistry, solubility, and sorption behavior of the relevant radionuclides. The chemical conditions in the vaults are controlled by the dissolution of the soluble constituents of the cement and by the corrosion of the iron waste containers and activated metals. As this corrosion takes place, slow changes will occur in the vault chemical conditions (page D-30).

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
4.2.2 *For purposes of the PA during operations or for closure, is all waste included in the source term?*	The PA considers waste disposed of from September 26, 1988 to December 31, 1997, for estimating waste inventories over the projected period of facility operation (page A-17).	Since this is a new facility that has not been operational, this question does not apply. This PA was prepared using reasonable, but conservative, parameter values to calculate disposal facility inventories that will meet the performance objectives. Implementation of these limits as waste acceptance criteria and waste certification program will provide reasonable assurance that the performance objectives will be met (page 5-2). The operational period for these facilities is expected to be at least 20 years (page 3-10). This PA assumed that 100 acres would provide disposal capacity for these 20 years of operation. These 100 acres would include 20 IL vaults and 21 LAW vaults (page 2-49). Assuming adequate funding is maintained at the SRS, these facilities are projected to be in operation by the year 2000 (page 1-3).
4.2.3 *What is the source of scaling factors for indirectly measured radionuclides?*	The ORNL identified the key radionuclides that were disposed of at each disposal facility. The list of key radionuclides was expanded further to include any radionuclide that represented >0.1% of the concentration limit developed in the draft PA dated September 1990. Radiation survey data were obtained for each waste package. The survey dose rate was converted to curies using a standard ORNL conversion factor. The distribution of the activity for each key radionuclide was determined by the generator and is not described in the PA. This method has some uncertainties based on the radionuclides involved and the geometry and shielding involved in the measurement. Evaluations of the activity determinations were done and calculations determined the uncertainties associated with the data (pages A-18 to A-26).	Not applicable

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
5. Pathways 5.1 Site Characteristics 5.1.1 *Must data about site characteristics meet any quality requirements in order to be used in the PA?*	There is no information in this PA about the quality requirements for the data on site characteristics. Each stage in the modeling uses simplifying assumptions involving inexact parameters and variables. The influence of the uncertainty in model parameters on the predicted contaminant concentrations is typically estimated by means of a parameter variance study. Such a study was carried out by Latin Hypercube (LHC) sampling of the parameters, whose variability is assumed to be represented by appropriate probability distributions. The uncertainty in the model parameters associated with each stage contributes to an overall uncertainty in the final projected contaminant concentration and dose (page H-1). It is recognized that the model is not likely to produce a computed concentration without errors. The uncertainty associated with asserting that the actual contaminant concentration is in compliance is assumed to come from two basic sources: (1) given that the model is an accurate representation of the transport process, the physical parameters are never known exactly; (2) the composite model may be flawed in the sense that it is not sufficiently specific to adequately describe the site and its details and, at the same time, is not sufficiently robust to describe the site for tens of thousands of years (page H-2).	Contributors to this PA conducted pertinent activities of the project under the guidance of the provisions of ANSI/ASME NQA-1 program requirements for Nuclear Facilities (page 3-99).
5.1.2 *What requirements are there to avoid the potential for "masking" from nearby nuclear facilities?*	No discussion was found in the PA on potential masking of SWSA 6 contamination by contamination from nearby nuclear facilities.	Several wells were installed to obtain background data for the EAV and to monitor the facility for startup. Several wells monitored at the EAV and up gradient to the EAV contained contaminants above the drinking water standards. This contamination was due to tritium, radium, tetrachloroethylene, and trichloroethylene (page 2-38).
5.2 Waste Distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to the most exposed individual?*	Each disposal unit was assumed to be a uniform composition (i.e., homogeneously heterogeneous in an engineering sense). The waste was taken to have an average open-pore void fraction of 0.27, and the concrete, of 0.15 (page 3-31).	No specific mention of the distribution of the waste in the disposal units was found. However, the discussions lead me to believe that the waste was considered to be a uniform composition.

Table D-4. (continued).

Parameter	ORNL (SWSA 6)	SRS (E-Area Vaults)
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to a hypothetical inadvertent intruder?*	For the agriculture scenario, an intruder is assumed to construct a house directly on top of a disposal unit with the foundation extending into the waste itself. Waste is assumed to be exhumed during the construction of the foundation and the waste is assumed to be indistinguishable from native soil. Some of the exhumed waste is assumed to be mixed with native soil in the intruder's vegetable garden and the following exposure pathways are assumed to occur: 1. ingestion of vegetables grown in the contaminated soil; 2. direct ingestion of contaminated soil from the garden in conjunction with vegetable intakes; 3. external exposure to contaminated soil while working in the garden or residing in the home on top of the disposal facility; and 4. inhalation of radionuclides suspended into air from contaminated soil while working in the garden or while residing in the home (page 3-21).	No specific mention of the distribution of the waste in the disposal units was found. However, the discussions lead me to believe that the waste was considered to be a uniform composition.

Table D-5. Non-DOE Performance Assessment Practices, Texas, California, and Nebraska.

Parameter	Texas	California	Nebraska
1. General 1.1 Format & content 1.1.1 *What is the general format? What are the contents for the PA?*	As an agreement state, the Texas regulations closely parallel the NRC's 10 CFR 61. Because the Texas regulatory agency has not issued separate guidance, the developing agency has based the format and content of the performance assessment on the NRC guidance.	California's disposal regulations incorporate 10 CFR 61 by reference. Therefore, the state regulations are virtually identical to the federal. Because the state did not issue separate guidance, the developing organization based the format and content of the performance assessment on NRC guidance.	The License Program Plan Manual issued by the Dept. of Environmental Quality and the Dept. of Health prescribes that applicants follow the format and contents in NUREG-1199, and NUREG-1200. The Manual also cites other NUREG documents as state guidance.
1.2 Approval process 1.2.1 *What is the formal process for final approval?*	The initial performance assessment is approved as part of the licensing process.	The initial performance assessment is approved as part of the licensing process. Other agencies have also reviewed elements of the performance assessment in conjunction with NESHAPS (EPA), and the transfer of land from the Federal government (Dept. of Interior).	The initial performance assessment is approved as part of the licensing process. As part of its review, the state conducts its own independent PA using different computer codes in order to evaluate the results of the PA presented in the application.
1.3 Review process 1.3.1 *What formal process does the PA go through before submittal for approval?*	The PA itself was peer reviewed by the applicant, the Texas LLRW Disposal Authority, and its contractors prior to formal review as part of the license application.	The site developer, US Ecology, submitted the performance assessment to an in-house team of independent technical reviewers.	
1.4 PA maintenance 1.4.1 *Is PA reviewed and updated as parameters change?*	The PA will be revised and updated once source term data reflecting actual waste disposed, and field data become available.	The PA will be revised and updated once source term data reflecting actual waste disposed, and field data become available.	The PA will be revised and updated once source term data reflecting actual waste disposed, and field data become available.
1.5 Method for Evaluating Uncertainty 1.5.1 *Deterministic-tic or probabilistic? What kind of uncertainty or sensitivity analysis, if any?*	The PA takes a deterministic approach using conservative assumptions, with sensitivity analyses of critical parameters.	The PA takes a deterministic approach using conservative assumptions, with sensitivity analyses of critical parameters.	The PA takes a deterministic approach using conservative assumptions, with sensitivity analyses of critical parameters.
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process, itself?*	No	No	No.
1.6.2 *Does the code approval/ review process include Validation? Verification?*	The QA program required by the state requires verification of any codes used in PA.		

Table D-5. (continued).

Parameter	Texas	California	Nebraska
2. Receptor (most exposed individual) 2.1 Receptor scenario 2.1.1 *What are the general (non-site-specific assumptions?)*	The scenarios are consistent with those described in NRC guidance. In general, the maximally exposed individual lives and works as close to the site as possible and derives all sustenance from sources adjacent to the site.	Twenty-five separate scenarios are used to model dose to the maximally exposed individual. The assumptions vary by scenario. In general, maximally exposed receptors live and work as close to the site as possible and derive all sustenance from sources adjacent to the site.	The scenarios are consistent with those described in the NRC's draft BTP on PA. An individual drills a well at the site boundary, drinks water from the well, eats produce irrigated from the well, and consumes livestock watered from the well. Inhalation is considered along with ingestion.
2.1.2 *What site-specific assumptions are used?*	Although field data did not suggest a groundwater pathway, an assumption was made that eventually a portion of the source term would make its way to the groundwater. Most of the waste was assumed to migrate upward based on water potential gradients measured at the site. Food uptake pathways were examined although the site location makes it doubtful that farming could take place.	No special credit is taken for the remoteness of the disposal site location.	An offsite wetland is included in the performance assessment. (See *time of compliance*, below.)
2.1.3 *Are variations used to model against possible future environmental conditions?*	Global climatic change was not assumed. Variations in rainfall which directly impacted infiltration rates (the key parameter limiting transport at the site) was evaluated.	Global climate change was not assumed. However, climatological events far in excess of expected values were used as assumptions in evaluating compliance with performance objectives.	Consistent with federal guidance, global climatic change was not assumed.
2.2 Dose standard 2.2.1 *What dose value to the individual is the standard?*	Assessment was conducted using ICRP 26/30 methodology so that doses are effective dose equivalents (EDE) not directly comparable to the regulatory limit. Based on discussions with the NRC, it may require all state regulations to be amended to conform with the 15 mrem EDE proposed by EPA.	The current regulatory standard of 25/75/25 mrem/yr to the most exposed individual was used. (See federal regulatory requirements.) In addition dose standards of 100 mrem/yr offsite gamma (10 CFR 20); 4 mrem/yr for primary drinking water (40 CFR); and 10 mrem/yr for NESHAPS (40 CFR) were used.	The current regulatory standard of 25/75/25 mrem/yr to the most exposed individual was used. (See federal regulatory requirements.)
2.3 Point of compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	At the boundary of the licensed disposal site (as opposed to the larger property boundary).	The point of compliance differed for different scenarios, including at the fence line, directly over waste trenches, or at the nearest residence.	Particle tracking was used to determine the point of maximum exposure on the site boundary for the water well scenario.
2.4 Time of compliance 2.4.1 *What is the time of compliance? (Time certain or peak dose?)*	For each radionuclide the time to peak dose was reported since the codes allow for such an analysis.	Measurements were made to either peak dose or to a time-certain depending on the specific radionuclide. Dose contribution for extremely long-lived radionuclides were made to specific times.	Exposure was variously calculated to: the time of peak concentration at the site boundary well, at the time of peak concentration at the wetland, at the end of transport simulations (10,000 years) and the worst case.

Table D-5. (continued).

Parameter	Texas	California	Nebraska
2.4.2 *What assumptions are made about future land ownership /control?*	Same as federal regulatory guidance.	Same as federal regulatory guidance.	Same as federal regulatory guidance.
2.4.3 *What institutional control period is used?*	Same as federal regulatory guidance.	Same as federal regulatory guidance.	Same as federal regulatory guidance.
2.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	Same as federal regulatory guidance.	Same as federal regulatory guidance.	Same as federal regulatory guidance.
2.5 Dose conversion 2.5.1 *What is the source of dose conversion factors? What assumptions are used?*	EPA Federal Guidance Report Nos. 11 and 12 are the primary sources. Ingrowth was considered by assuming that the short lived daughters of Pb-210, Pa-226, Th-228, Th-232, U-235 and U-238 are in equilibrium with the parent and the dose conversion factors are summed unless the source indicated that this had already been done. Pu-241 and Am-241 were transformed to equivalent concentrations of Np-237 and analyzed as if they were neptunium.	The library of dose conversion factors is derived from RADRISK, a modified INREM-II Code (ORNL/NUREG/TM-84, June 1978)	
3. Receptor (inadvertent intruder) 3.1 Receptor scenario 3.1.1 *What are the general (non-site-specific assumptions?*	Although not specifically required by state or federal regulations, selected scenarios in NUREG-1199 applicable to the site location were used to calculate the dose to an inadvertent intruder.	Selected scenarios were run to calculate potential dose to an inadvertent intruder. The bounding case was the "basement gas scenario."	See federal regulatory requirements. Because the waste classification and disposal system include technical requirements to prevent the inadvertent intruder from contacting the waste, no dose is assumed.
3.1.2 *What site-specific assumptions are used?*	A scenario was run wherein an intruder drilled a well over a Class C waste canister filled with ion exchange resins.	The basement gas scenario assumes a house is built over B/C-30 trench after the end of the institutional control period.	Not applicable (see above)
3.1.3 *Are variations used to model against possible future environmental conditions?*	No	Not applicable (see above)	Not applicable (see above)
3.2 Dose standard 3.2.1 *What dose value to the individual is the standard?*	Same as standard used by the NRC, 500 mrem per year.	Not applicable (see above)	Not applicable (see above)

Table D-5. (continued).

Parameter	Texas	California	Nebraska
3.3 Point of compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	Above a Class B/C disposal unit immediately at the end of the 100-year institutional control period.	Not applicable (see above)	Not applicable (see above)
3.4 Time of compliance 3.4.1 *What is the time of compliance? (Time certain or peak dose?)*	Dose is reported for the scenario through 10,000 years.	Not applicable (see above)	Not applicable (see above)
3.4.2 *What assumptions are made about future land ownership and control?*	Same as federal regulatory guidance.	Not applicable (see above)	Not applicable (see above)
3.4.3 *What institutional control period is used?*	Same as federal regulatory guidance.	Not applicable (see above)	Not applicable (see above)
3.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	Active controls cease to exist at the end of institutional control. Passive controls such as the concrete canisters fail at 100 years for Class A waste and 300 years for Class B/C waste.	Not applicable (see above)	Not applicable (see above).
3.5 Dose conversion 3.5.1 *What is the source of dose conversion factors? What assumptions are used?*	Same as source of dose conversion for most exposed individual, see above.	Not applicable (see above)	Not applicable (see above)
4. Release Mechanism 4.1 Waste inventory 4.1.1 *How are records on waste inventory kept to ensure their integrity?*	Records for each shipment will be checked and verified. They will be stored in electronic format. It is anticipated that records will be subject to audit.	US Ecology procedure is to enter records of waste received daily into its data base, which is backed up daily. Hard copies of the records are stored in fireproof cabinets and microfilmed copies are stored offsite at multiple locations.	Records of waste received, the location of waste in the disposal units, and other information will be held by the licensee until expiration of a retention period to be specified by the regulatory agency. At the end of the retention period, the records are transferred to the licensing agency.
4.1.2 *For currently operating sites, how does record keeping today differ from the past?*	Not applicable	Not applicable	Not applicable
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory, for purposes of PA?*	Not applicable	Not applicable	Not applicable

Table D-5. (continued).

Parameter	Texas	California	Nebraska
4.2 Source term 4.2.1 *What assumptions are made about the release of radionuclides from the various waste forms?*	After it is assumed that the concrete canisters and the waste form fail, some water will percolate through the disposal unit cover system and contact the waste. Neither surface washoff or dissolution are expected to be significant. Leaching will be dominated by diffusion. Except for the release of radioactive gases, nuclides are assumed to leave the disposal unit only with percolating water (advection). The maximum leach rate occurs at the time of failure of the waste form or canister. This leach rate is used throughout the PA calculations.	No credit was taken for waste packaging (except for high integrity containers containing certain Class B and C wastes). The bounding case scenario assumed that all waste was available for transport.	
4.2.2 *For purposes of PA during operations or for closure, is all waste included in the source term?*	Yes	Yes	Yes
4.2.3 *What is the source of scaling factors for indirectly measured radio-nuclides?*	Shipping manifests for actual waste shipped for disposal in the past from the region are used for the source term. These do not indicate the source of scaling factors for indirectly measured radionuclides. Disposal permit requirements in states where waste has been disposed have required waste generators preparing these manifests to use scaling methods that have been approved by regulatory agencies.	Shipping manifests for actual waste shipped for disposal in the past from the region are used for the source term. These do not indicate the source of scaling factors for indirectly measured radionuclides. Disposal permit requirements in states where waste has been disposed have required waste generators preparing these manifests to use scaling methods that have been approved by regulatory agencies.	The source inventory (except Tc-99) was based on records for waste shipped for disposal from the Central Compact region from generators that produced more than 10 cubic feet per year. The source term for I-129 and Tc-99 were modeled using the 3R-Stat code, which was recently approved by the NRC. Only radionuclides with half-lives greater than 10 years are considered in the groundwater transfer mechanism. Groundwater modeling begins at the end of the 30-year operational life.
5. Pathways 5.1 Site characteristics 5.1.1 *Must data about site characteristics meet any quality requirements or standards in order to be used in PA?*	Same as federal regulatory guidance. The Texas LLRWD Authority uses NUREG-1293 as the basis of its QA program.	Same as federal regulatory guidance.	Same as federal regulatory guidance.
5.1.2 *What is done to avoid the potential for "masking" from nearby nuclear facilities?*	There are no nearby nuclear facilities.	There are no nearby nuclear facilities.	There are no nearby nuclear facilities.

Table D-5. (continued).

Parameter	Texas	California	Nebraska
5.2 Waste distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Most Exposed Individual?*	Waste is assumed to be uniformly distributed throughout the disposal units.	Waste is assumed to be uniformly distributed within the respective disposal units. The source term in BC/30 trench was limiting. A separate tritium analysis assumed a 100' by 100' footprint for preferential migration.	The entire class A inventory is assumed to be in one Class A cell. The entire Class B/C waste inventory is assumed to be in one B/C cell.
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Inadvertent Intruder?*	The inadvertent intruder is assumed to drill a well that penetrates a 200 cubic foot liner containing ion exchange resins that at the time of disposal contain Cs-137 at the Class C concentration limit.	Not applicable. See *Receptor Scenario* for inadvertent intruder, above.	Drums of spent resin are used in the inadvertent intruder scenario, to provide a worst case scenario. [Was modeling done on an *inadvertent intruder* scenario? See above]

Table D-6. Non-DOE Performance Assessment Practices, North Carolina, Washington, and South Carolina.

Parameter	North Carolina	Washington	South Carolina
1. General 1.1 Format & content 1.1.1 *What is the general format? What are the contents for the PA?*	North Carolina is an agreement state and has adopted regulations similar to 10 CFR 61. The portion of the license application dealing with PA is patterned after section 6 of NUREG-1200, which addresses the safety assessment of a proposed disposal site.	*[Plans for closure of the Richland, WA, site are currently under review by the WA Department Of Health. The PA assumptions used in the plan may be subject to change before the plan is approved, and are therefore not reported here.]*	*[Prior to issuance of 10 CFR 61, the NRC conducted an Environmental Assessment of the Barnwell facility (NUREG-0879, January 1982). Based on computer modeling, the dose to a hypothetical resident living outside the facility was "conservatively" estimated at less than 15 mrem per year, with tritium as the controlling radionuclide. In 1995 the state was planning to hire an independent contractor to update the PA as part of the closure plan when the State General Assembly enacted legislation keeping the disposal facility open past 1995. Because the site does not plan to close in the near future, work on the closure plan, including the PA, has been discontinued. Therefore, there is no current PA information on the site.]*
1.2 Approval process 1.2.1 *What is the formal process for final approval?*	The initial performance assessment is approved as part of the overall process for approving the license application and issuing an operating license.		
1.3 Review process 1.3.1 *What formal process does the PA go through before submittal for approval?*	A management review group within Chem-Nuclear, the license applicant, conducted a formal peer review. The NC LLRW Authority did not formally review and approve the PA.		
1.4 PA maintenance 1.4.1 *Is PA reviewed and updated as parameters change?*	The PA will be revised and updated once source term data reflecting actual waste disposed, and field data become available.		
1.5 Method for Evaluating Uncertainty 1.5.1 *Deterministic or probabilistic? What kind of uncertainty or sensitivity analysis, if any?*	Based on a report from an independent consultant, the NC LLRW Authority has directed Chem-Nuclear to make revisions to the license application that would better account for uncertainty and propagation of error. The revised approach would make more use of site-specific data on fractures, dikes and faults.		
1.6 Computer Codes 1.6.1 *Is there an approval process for PA codes that is separate from the PA approval process, itself?*	No		

Table D-6. (continued).

Parameter	North Carolina	Washington	South Carolina
1.6.2 *Does the code approval/ review process include Validation? Verification?*	The applicant plans to use only codes that have already been validated and verified.		
2. Receptor (most exposed individual) 2.1 Receptor scenario 2.1.1 *What are the general (non-site-specific assumptions?)*	The scenario is consistent with that described in the NRC's draft BTP on PA. The scenario involves a person who sustains himself at the site by drinking water, eating crops and feeding livestock from a well at the site border.		
2.1.2 *What site-specific assumptions are used?*	At this site, a scenario built around an adjacent resident is not credible because of the lack of groundwater. At the wettest spot, which is considerable distance off site, only 8 gallons per minute are obtained.		
2.1.3 *Are variations used to model against possible future environmental conditions?*	Consistent with federal guidance, global climatic change was not assumed.		
2.2 Dose standard 2.2.1 *What dose value to the individual is the standard?*	The license application is being revised to report against a 15 mrem Committed Effective Dose (CED), in anticipation of regulatory changes.		
2.3 Point of compliance 2.3.1 *Where is the most exposed individual located with respect to the disposal site?*	The individual is located at the edge of the buffer zone, which is 1000 feet from the edge of the disposal units. This point of compliance is currently under review and may be changed.		
2.4 Time of compliance 2.4.1 *What is the time of compliance? (Time certain or peak dose?)*	For each radionuclide the time to peak dose was reported since the codes allow for such an analysis.		
2.4.2 *What assumptions are made about future land ownership/ control?*	The state owns or will own land surrounding the site, but is not taking credit for the additional land in setting the point of compliance.		

Table D-6. (continued).

Parameter	North Carolina	Washington	South Carolina
2.4.3 *What institutional control period is used?*	Same as federal regulatory guidance. The disposal facility licensee/operator may apply for transfer of the license to the custodial agent (the state) upon closure of the facility. Financial assurance arrangements must be in place to ensure resources for a 100-year institutional control period.		
2.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	Water collection sumps located at either end of each disposal unit, a design feature associated with active controls, are designed to remain open permanently. (This design feature may be changed.)		
2.5 Dose conversion 2.5.1 *What is the source of dose conversion factors? What assumptions are used?*	International standards will be used.		
3. Receptor (inadvertent intruder) 3.1 Receptor scenario 3.1.1 *What are the general (non-site-specific assumptions?*	See federal regulatory requirements. Because the waste classification and disposal system include technical requirements to prevent the inadvertent intruder from contacting the waste, no dose is assumed.		
3.1.2 *What site-specific assumptions are used?*	Not applicable (see above)		
3.1.3 *Are variations used to model against possible future environmental conditions?*	Not applicable (see above)		
3.2 Dose standard 3.2.1 *What dose value to the individual is the standard?*	Not applicable (see above)		
3.3 Point of compliance 3.3.1 *Where is the most exposed individual located with respect to the disposal site?*	Not applicable (see above)		
3.4 Time of compliance 3.4.1 *What is the time of compliance? (Time certain or peak dose?)*	Not applicable (see above)		

Table D-6. (continued).

Parameter	North Carolina	Washington	South Carolina
3.4.2 *What assumptions are made about future land ownership and control?*	Not applicable (see above)		
3.4.3 *What institutional control period is used?*	Not applicable (see above)		
3.4.4 *What assumptions are made about active and passive controls that may affect modeling?*	Not applicable (see above)		
3.5 Dose conversion 3.5.1 *What is the source of dose conversion factors? What assumptions are used?*	Not applicable (see above)		
4. Release Mechanism 4.1 Waste inventory 4.1.1 *How are records on waste inventory kept to ensure their integrity?*	North Carolina regulations prescribe detailed requirements. These include transfer of quarterly reports including the location and inventory of disposed waste. A copy of the report is filed with the State Records Center for permanent retention.		
4.1.2 *For currently operating sites, how does record keeping today differ from the past?*	Not applicable		
4.1.3 *Where past records are not up to today's standards, what is done to estimate waste inventory, for purposes of PA?*	Not applicable		
4.2 Source term 4.2.1 *What assumptions are made about the release of radionuclides from the various waste forms?*	In the license application, the anticipated waste forms were grouped into categories based upon partitioning characteristics. (This approach is currently being reviewed.)		
4.2.2 *For purposes of PA during operations or for closure, is all waste included in the source term?*	Yes		

Table D-6. (continued).

Parameter	North Carolina	Washington	South Carolina
4.2.3 *What is the source of scaling factors for indirectly measured radio-nuclides?*	Shipping manifests for actual waste shipped for disposal in the past from the region are used for the source term. These do not indicate the source of scaling factors for indirectly measured radionuclides. Disposal permit requirements in states where waste has been disposed have required waste generators to use scaling methods that have been approved by regulatory agencies.		
5. Pathways 5.1 Site characteristics 5.1.1 *Must data about site characteristics meet any quality requirements or standards in order to be used in PA?*	Same as federal regulatory guidance.		
5.1.2 *What is done to avoid the potential for "masking" from nearby nuclear facilities?*	The site is located near a lake on the opposite side from the Shearon Harris nuclear power plant. Groundwater gradients at the disposal site go toward the lake. The monitoring program is designed in a manner that will differentiate migration between the power plant and the disposal facility. Environmental monitoring information will be routinely shared between the power plant and the disposal site.		
5.2 Waste distribution 5.2.1 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Most Exposed Individual?*	In the PA in the license application, concentrations for each radionuclide were calculated by dividing total inventory by total waste volume. Categories of anticipated waste forms were considered separately. This approach is currently being revised.		
5.2.2 *What assumptions are made about the distribution of waste in disposal units for calculating dose to Inadvertent Intruder?*	Not applicable (see above)		

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