Draft Branch Technical Position on Concentration Averaging and Encapsulation, Revision 1

U.S. Nuclear Regulatory Commission

Office of Federal and State Materials and Environmental Management Programs

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BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

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1 Introduction

The U.S. Nuclear Regulatory Commission (NRC) licensing requirements for land disposal of radioactive waste (Title 10 of the Code of Federal Regulations (10 CFR) Part 61, “Licensing Requirements for land Disposal of Radioactive Waste”) include four performance objectives. These performance objectives are as follows:

- protection of the general population from releases of radioactivity,
- protection of inadvertent intruders,
- protection of individuals during operations, and
- stability of the disposal site after closure.

A low-level radioactive waste (LLRW) disposal facility must be designed, operated, closed, and controlled after closure so that reasonable assurance exists that these performance objectives will be met. At some point in time after active institutional controls over the disposal site are removed, the NRC postulates that an individual unknowingly intrudes onto the disposal site and interacts with the waste. To protect this hypothetical individual, the NRC developed a waste classification system (10 CFR § 61.55, “Waste classification”) that requires greater control measures for waste with greater radionuclide concentrations. As stated in 10 CFR § 61.13, “Technical analyses,” analyses of the protection of individuals from inadvertent intrusion must include a demonstration that there is reasonable assurance that the waste classification requirements will be met.

This Branch Technical Position (BTP) on Concentration Averaging and Encapsulation provides guidance for waste generators and processors classifying waste for disposal. This BTP presents acceptable methods by which radionuclide concentrations in specific waste streams or mixtures of these waste streams may be averaged over the volume or mass of the waste. This BTP provides guidance on complying with 10 CFR § 61.55(a)(8) as it applies to the classification of waste for disposal under 10 CFR Part 61. The NRC is revising the BTP to improve its clarity; to update the position on LLRW blending, as directed by the Commission (NRC, 2010); and to align the BTP with the agency’s direction of providing a risk-informed performance-based regulatory approach.

NRC regulations require that the waste class be identified for each disposal container in a shipment of radioactive waste to a licensed LLRW land disposal facility. This information is reported on a shipping manifest as specified in Appendix G, “Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests,” to Part 20, “Standards for Protection Against Radiation,” of NRC’s regulations. Licensees that ship waste are required to certify that each waste package listed on the manifest is properly classified as Class A, B, or C in accordance with 10 CFR § 61.55, “Waste classification.” As the waste class increases from Class A to Class C, the hazard to an inadvertent intruder increases. This BTP addresses the classification of individual waste containers to help facilitate compliance with the Appendix G requirements. Guidance for averaging across multiple waste containers is outside the scope of this BTP.

For classifying wastes as Class A, B, or C, 10 CFR § 61.55(a)(8) states that "…the concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram." This BTP provides guidance on complying with 10 CFR § 61.55(a)(8) as it applies to the classification of specific wastes and mixtures of wastes for disposal under 10 CFR Part 61. The basis for the averaging provisions in this BTP is protection of the inadvertent intruder (i.e., averaging constraints and criteria are specified that will ensure that the intruder will continue to be protected). This guidance does not in any way alter a licensee's obligation to meet the waste classification concentration limits in 10 CFR § 61.55.

The NRC's waste classification system is generic; that is, it applies to all LLRW disposal sites. All generators and waste processors that ship waste to any licensed disposal site can use this system, which helps to ensure that the disposal facility receiving the waste applies the required control measures assigned to each waste class to ensure safe disposal. The generic 10 CFR § 61.55 waste classification tables do not take into account any site-specific features or considerations, but licensees could perform site- or waste-specific intruder analyses to justify alternative waste classification provisions. Under 10 CFR § 61.58, "Alternative requirements for waste classification and characteristics," the Commission could approve these alternative provisions if it found that there was reasonable assurance of compliance with the Subpart C. "Performance Objectives" to 10 CFR Part 61, including the performance objective for protection of an inadvertent intruder in 10 CFR § 61.42, "Protection of individuals from inadvertent intrusion."

The averaging provisions recommended in this document are also generic (i.e., the staff believes they are suitable for use by any licensed disposal facility or generators or processors shipping waste to a licensed disposal facility). Although this approach may simplify classification for generators, there may be instances in which generators, processors, or disposal facility operators wish to apply site-specific averaging approaches, approved by the regulator of the facility. This BTP provides examples of site-specific considerations for averaging that may be useful to licensees that propose alternative approaches and to regulators that must review these proposals.

Although Agreement States are required to adopt waste classification regulations that are essentially identical to the NRC's in 10 CFR § 61.55,[1] they may use averaging approaches that differ from those contained in this guidance. Therefore, waste generators should ensure that the disposal facility license conditions related to waste classification and averaging are met before shipping waste to a licensed disposal facility. Consultation with disposal facility operators may be needed.

2 Relationship between 1983 BTP, 1995 BTP and this BTP

On May 11, 1983, the NRC published "Final Waste Classification and Waste Form Technical Position Papers" (NRC, 1983). The 1983 guidance described overall procedures acceptable to the NRC staff that licensees may use to determine the presence and concentrations of the

[1] 10 CFR § 61.55 is NRC compatibility Category B. This category is for activities that have direct and significant transboundary implications.

radionuclides listed in 10 CFR § 61.55, and thereby classify waste for near-surface disposal. The initial "Technical Position on Waste Classification" included Section C.3, "Concentration Volumes and Masses," which provided guidance to waste generators on the interpretation of 10 CFR § 61.55(a)(8). On January 17, 1995, the NRC replaced Section C.3 of the 1983 Technical Position with the "Branch Technical Position on Concentration Averaging and Encapsulation," (NRC, 1995). The other sections of the 1983 Technical Position remain in effect, with the exception of the corrections noted in the footnote below.[2]

In the *Federal Register* notice announcing the availability of the 1995 BTP (NRC 1995), the NRC stated that the BTP was developed for two reasons. First, it was considered desirable to attempt to achieve consistent waste classification positions among the Commission and Agreement State regulatory authorities. Second, the staff noted that the waste classification positions could affect other programs (e.g., the U.S. Department of Energy's (DOE's) program to accept greater-than-Class C waste).

In addition, after the finalization of 10 CFR Part 61, there were a number of well-publicized accidents involving small, highly radioactive sealed sources.[3] The nature of these accidents led the NRC to consider individual gamma-emitting items that might survive in a LLRW disposal facility and to consider the possibility that their radioactive nature would not be recognized by an inadvertent intruder. To ensure that individual gamma-emitting items do not compromise the protection of the inadvertent intruder, the 1995 BTP introduced exposure scenarios that assessed the possible dose consequences to an inadvertent intruder unknowingly handling an individual LLRW item 500 years after disposal. The results from the technical analysis of the handling scenarios are the basis for the majority of the positions in the 1995 BTP. These 1995 positions limit "hot spots"[4] (highly concentrated item(s)) in mixtures of wastes and also set limits on encapsulation practices.

Like the 1995 BTP, this updated BTP recommends limits on hot spots and provides guidance for classifying different "waste types." As used in this BTP, waste types include: various homogeneous types (e.g., spent ion exchange resins mixed as part of the design of a nuclear power plant, contaminated soils, and filter media); activated metals; contaminated materials; cartridge filters and sealed radioactive sources. Appendix A of this document provides a glossary of terms used in this BTP.

This BTP replaces the 1995 BTP on Concentration Averaging and Encapsulation in its entirety, as well as Section C.3 of the 1983 BTP. Consistent with NRC policy, this revision is more risk-informed and performance-based than the 1995 BTP. The technical bases for the positions in this BTP are presented in Appendix B, and a brief description of the changes between the 1995 BTP and this BTP are provided in Appendix I.

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[2]The following corrections should be made to the May 1983, Technical Position: (1) p.1 first para., fourth line—delete the words, "or processor"; and (2) p.6, fourth line and p.12, second para., fifth line—replace "biannual" with "biennial."
[3] For example, see International Atomic Energy Agency (IAEA) 1988.

[4] See Glossary in Appendix A for definition

3 Safety Culture

It is the NRC's expectation that individuals and organizations performing regulated activities establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions. This applies to all licensees, certificate holders, permit holders, authorization holders, holders of quality assurance program approvals, vendors and suppliers of safety-related components, and applicants for a license, certificate, permit, authorization, or quality assurance program approval, subject to NRC authority. "Nuclear safety culture" is defined as the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment. Individuals and organizations performing regulated activities bear primary responsibility for safely handling and securing these materials. Experience has shown that a positive safety culture exhibits certain personal and organizational traits. A trait, in this case, is a pattern of thinking, feeling, and behaving that emphasizes safety, particularly in goal conflict situations (e.g., production versus safety, schedule versus safety, and cost of the effort versus safety).

The NRC, as the regulatory agency with an independent oversight role, reviews the performance of individuals and organizations to determine compliance with requirements and commitments through its existing inspection and assessment processes. However, the NRC's safety culture policy statement and traits are not incorporated into the regulations. Many of the safety culture traits may be inherent to an organization's existing radiation safety practices and programs.

Refer to Appendix J for the NRC's Safety Culture Policy Statement. More information on NRC activities related to safety culture can be found at: http://www.nrc.gov/about-nrc/regulatory/enforcement/safety-culture.html.

4 Technical Position

The following paragraphs provide guidance on acceptable approaches for concentration averaging, including mixing and encapsulation practices for the classification of LLRW. This guidance is not intended to address all unique waste types or waste packaging methods. Other provisions for the classification or encapsulation may be deemed acceptable, as discussed under Section 4.9, "Alternative Approaches for Averaging."

To improve clarity, flowcharts of the BTP's guidance are presented in Figure 2 and Figure 3. The Figure 1 flowchart outlines the steps for classifying mixtures of items of waste in a single waste container and homogeneous waste types. The Figure 2 flowchart outlines the steps for classifying individual items, and the Figure 3 flowchart outlines the steps for classifying mixable wastes. The position on encapsulation of sealed sources and other solid LLRW is provided in Section 4.5, "Encapsulation of Sealed Sources and Other Solid Low-Level Radioactive Wastes."

4.1 Waste Characterization

Waste characterization is the first step in waste classification. Waste characterization requires information about the volume and concentration of each nuclide in each item of waste. Waste classes are defined by radionuclide concentrations given in 10 CFR § 61.55, Tables 1 and 2. The concentrations in the tables were derived to protect an inadvertent intruder. The May 1983 Technical Position provides guidance on how to determine radionuclide concentrations. This BTP provides guidance on how to measure the volume of the waste for the purposes of classification in Section 4.6, "Determining the Volume of the Waste."

In general, the volume and nuclide concentration information about each individual item of waste must be sufficient to determine 10 CFR § 61.55 nuclide concentrations. If an item or a mixture of items contains more than one nuclide listed in Table 1 or in Table 2 of 10 CFR § 61.55, the volume and nuclide information must be used to calculate the "sum of fractions," as explained in 10 CFR § 61.55(a)(7). The individual pieces in a mixture should be evaluated to determine if there are radiological hot spots that could compromise the safety of an inadvertent intruder. If hot spots exist, they should be removed from the mixture and classified as individual items using the process shown in Figure 2. Classification of an individual item is addressed in Section 4.4 of this BTP, "Classifying Individual Items." After removal of the more concentrated items, the remaining mixture should be reevaluated using Figure 1. Once the mixture is brought within limits established in this BTP, the mixture can be classified based on the average concentration of all items remaining in the mixture.

If the sum of fractions exceeds 1 for the Table 1 values or exceeds 1 for column 3 of the Table 2 values, then the mixture exceeds the Class C limits and the licensee should determine if the mixture can be reconstituted to bring the sum of fractions below 1. Assuming that the sum of fractions for a mixture does not exceed 1 (for Table 1 or column 3 of Table Table 2), the first decision (decision node A) in Figure 1 is whether the disposal container holds a single item or multiple items. A container of solidified or absorbed liquid is considered to be a single item (Section 4.4).

The next decision (node B) is whether the waste is "mixable."[5] Mixable wastes, including homogeneous wastes, are classified according to guidance provided in Section 4.2 and outlined in Figure 3. Node C asks the first question concerning "waste types." Waste types are wastes that are grouped together for the purposes of this concentration averaging and waste classification BTP. Waste types include, but are not limited to: various homogeneous waste types (e.g., spent ion exchange resins mixed as part of the design of a nuclear power plant, contaminated soils, and filter media); activated metals; contaminated materials; cartridge filters, and sealed radioactive sources. A drum containing pieces of activated metal is an example of a container of wastes that are of a similar waste type.

An example of a container of dissimilar waste types is a drum containing miscellaneous trash (a homogeneous waste type) mixed with pieces of activated metal. At node C, if the disposal container holds a mixture of dissimilar waste types, and if the highest waste classification of any individual item of the mixture is not higher than the waste classification when compared to the total mixture (average of the total activity over the total volume or mass), then the classification

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[5] Mixable waste is waste that could easily be mixed to create relatively uniform radionuclide concentrations. Mixable waste is not necessarily homogeneous (e.g., if blending is insufficient). In this BTP, the term is used primarily to differentiate waste that is easily mixed from waste that is composed of discrete items (e.g., a group of pieces of activated metal is not considered mixable waste).

based on the average concentration may be used (node D). A container of dissimilar waste types that does not meet this criterion should be reconfigured, or the licensee can propose classifying the mixture according to the approaches outlined in Section 4.8, "Alternative Requirements" or Section 4.9, "Alternative Approaches for Averaging." Guidance for classifying mixtures of similar waste types (e.g., a container holding pieces of activated metals or contaminated materials or cartridge filters) is presented in Section 4.3, "Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters."

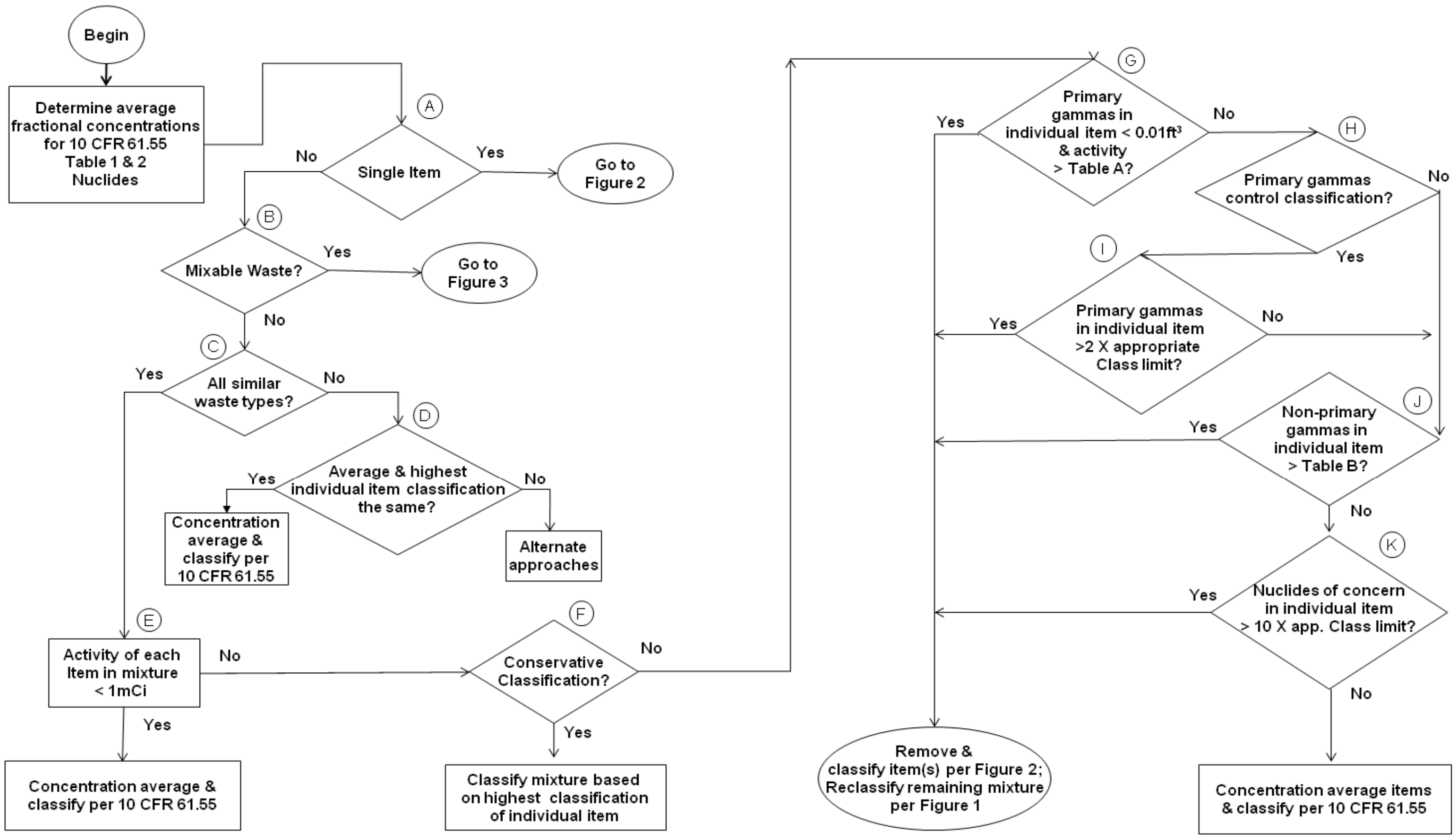

Figure 1. Classification of Mixtures of Activated Metals, Contaminated Materials and Cartridge Filters

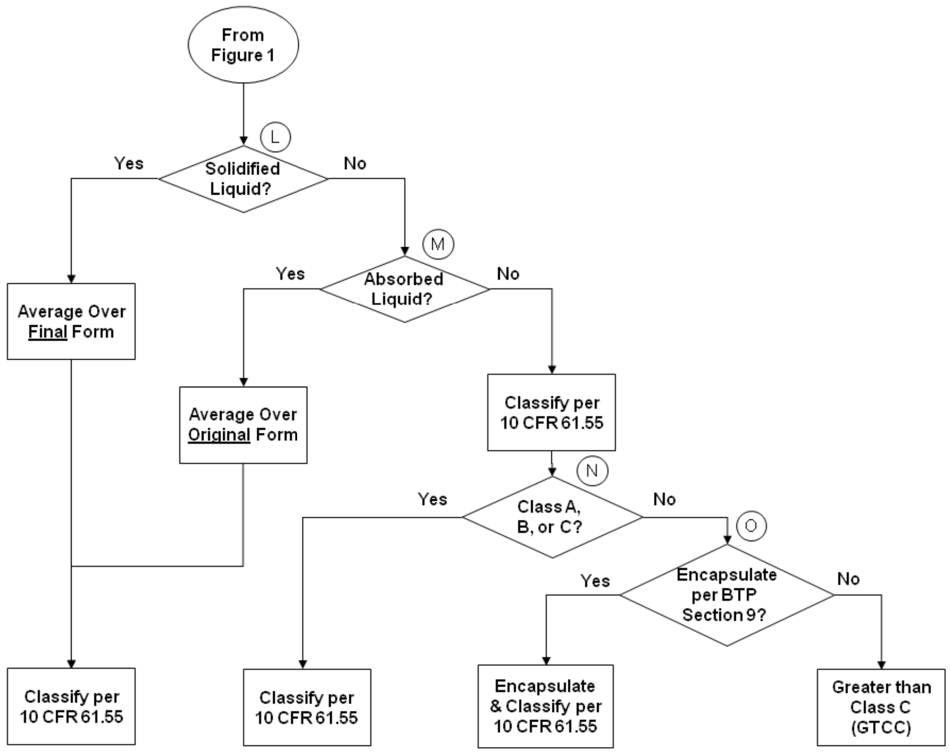

Figure 2. Classification of Individual Items

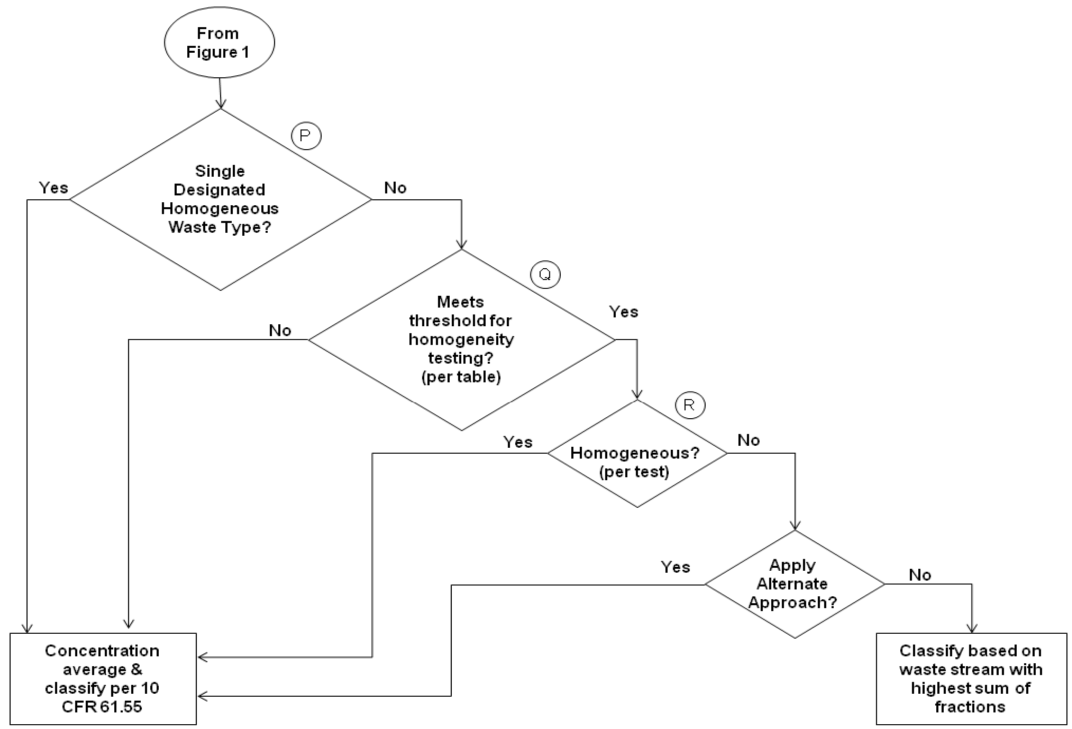

Figure 3. Concentration Averaging for Mixable Waste

4.2 Classifying Mixable and Homogeneous Waste

Waste that is amenable to physical mixing to achieve relatively uniform radionuclide concentrations is called mixable waste. Examples of mixable waste include soil, ion exchange resins, and ash. Mixable waste is not necessarily homogeneous (e.g., if blending is incomplete). Waste is homogeneous for classification if the concentrations of the "nuclides(s) of concern"[6] are likely to approach uniformity in the context of reasonably foreseeable intruder scenarios (see Glossary in Appendix A for the definition of "nuclides of concern"). Thus, mixibility is a physical property of the waste, whereas homogeneity, as used in this guidance, is a radiological property.

The concentration of homogeneous waste may be averaged over a waste container without constraint. That is, the classification of homogeneous waste may be based on the total radionuclide activity in a container divided by the volume (or mass, as appropriate) of waste in the waste container.

Wastes that are deemed to be homogeneous waste types (Section 4.2.1) or wastes that do not meet the threshold for demonstrating homogeneity (Section 4.2.2.1) may be considered homogeneous for waste classification. That is, the radionuclide concentrations in these wastes may be averaged over the waste container (see Figure 3). Wastes that meet the threshold for demonstrating homogeneity should be shown to be homogeneous through process knowledge, other reasoned conclusion, or, in some cases, by direct measurement (Section 4.2.2.2).

4.2.1 *Mixable Wastes and Homogeneous Waste Types*

Certain wastes may be treated as homogeneous waste types for the purpose of waste classification without specific demonstration of homogeneity. These wastes include solidified or absorbed liquid, spent ion-exchange resins mixed as part of the design of a nuclear power plant, filter media, evaporator bottom concentrates, and ash. Contaminated soil, contaminated trash, and containerized dry active waste (DAW) also may be classified as homogeneous under certain circumstances, as described below. The NRC considered solidified and absorbed liquids to be homogeneous waste types because radionuclide concentrations are expected to be uniform at the time of disposal. Spent ion-exchange resins mixed as part of the design of a nuclear power plant, filter media, evaporator bottom concentrates, ash, and contaminated soil are considered homogeneous waste types because they are mixable, and, based on NRC experience, the radionuclides in these waste streams are expected to be relatively uniformly distributed.

To the extent that contaminated trash, contaminated soil, and DAW are packaged in a disposal container to achieve ≥90 percent fill, the volumetric-averaged concentration of radionuclides in these waste types can be based on the fill-volume of the container. DAW, which may be

[6] In most cases, the risk-significant nuclides and the nuclides of concern will be the same. However, it is possible that the risk to an inadvertent intruder could be dominated by a radionuclide not included in Tables 1 and 2 of 10 CFR § 61.55 (e.g., depleted uranium). In these cases, intruder protection is maintained by the 10 CFR § 61.42 performance objective for protection of individuals against inadvertent intrusion.

composed of a variety of miscellaneous materials, may be considered a homogeneous waste type for purposes of waste classification when placed in containers because it is expected to degrade within approximately 100 years to a more well-mixed and soil-like state.

Alternatively, the volume of the waste can be calculated from the weight of the container contents divided by the density of the contents. A representative density, based on a representative distribution of materials as they occur in waste, may be used. The activity of small concentrated microcurie sources or gauges (< 3.7 megabequerel (MBq) [100 microcuries (μCi)]) that may be mixed with contaminated trash may be averaged over the trash volume.

Because of the low likelihood that an intruder would encounter a hot spot in a waste that typically is expected to be homogeneous, the NRC staff does not believe that any benefits realized by quantifying the homogeneity of these wastes would justify the additional dose incurred by workers making the measurements.

4.2.2 *Homogeneity of Mixable Waste*

Similar mixable waste streams (e.g., ion exchange resins from different facilities) may be physically blended irrespective of their initial radionuclide concentrations. As discussed in Section 4.2.1, the NRC staff has sufficient experience with certain waste streams to designate them as homogeneous waste types. This section addresses the homogeneity of other mixable waste streams (i.e., mixable waste streams not designated as homogeneous waste types). Section 4.2.2.1 provides threshold values above which demonstrating homogeneity is recommended. Waste produced in smaller quantities or from less concentrated waste than described in Section 4.2.2.1 can be treated as homogeneous waste (i.e., concentrations may be averaged over the waste container without constraint). Licensees should address the homogeneity of waste that meets the threshold through one of two processes: (1) demonstrating the waste is homogeneous, as described in Section 4.2.2.2, or (2) using an alternative approach to demonstrate that the waste does not present homogeneity concerns (Section 4.9).

Blending of physically dissimilar mixable waste streams (e.g., mixing ion exchange resins with soils) should be considered on a case-by-case basis. Proposals to blend physically dissimilar waste streams should address the physical and chemical compatibility of the waste streams. Specifically, waste streams that could cause undesirable chemical reactions (e.g., hydrogen generation) should not be blended.

4.2.2.1 *Threshold for Demonstrating Waste Homogeneity*

Mixing wastes with different radionuclide concentrations may create an intrusion hazard because of the potential creation of hot spots in the waste. If none of the influent waste streams being blended are very concentrated (relative to the class limit), the potential hazard is small. Similarly, if the amount of blended waste generated is small (relative to the amount of waste disposed of at a site), the probability an intruder will encounter a hot spot is small. Thus, a threshold for demonstrating homogeneity based on intruder protection depends on both the radionuclide concentrations in the influent waste streams (which affects the potential hazard from incompletely mixed waste) and the quantity of waste blended (which affects the chance an intruder will encounter the blended waste). To establish a threshold for demonstrating homogeneity, the NRC staff developed concentrations and volumes below which no specific demonstration of homogeneity is needed (Table 1). The NRC staff recommends that waste produced from combining mixable wastes in greater quantities, or composed of influent waste streams with greater concentrations, specifically be shown to be homogeneous (Section 4.2.2.2) before waste classification.

In the absence of any homogeneity testing, the activity and size of a hot spot in a waste package is limited only by the influent waste streams and the classification of the waste package as a whole. In a larger package, relatively more activity can be present in a hot spot while the package as a whole still meets the class limits. For example, in a 5 cubic meter (m^3) (180 cubic foot (ft^3)) waste container, approximately 0.05 m^3 (1.8 ft^3) could have a sum of fractions near 100 if the remaining waste has a very low activity. In a 4 m^3 (140 ft^3) waste package, the size of this hot spot falls to 0.04 m^3 (1.4 ft^3), and in a 3 m^3 (100 ft^3) package, it falls to 0.03 m^3 (1 ft^3). Alternately, for a fixed size of hot spot in a waste package meeting the class limit, the potential sum of fractions in a hot spot increases with package size. The potential dose to an inadvertent intruder depends on how much of this waste is encountered and how concentrated it is.

While an intruder exhuming many waste packages (e.g., an individual constructing a dwelling) will naturally homogenize waste over a relatively large volume, an intruder exhuming a relatively small volume of waste (e.g., a well driller) is more susceptible to encountering hot spots in the waste and averaging the exhumed waste over a much smaller volume. In general, radiological heterogeneity within a disposal container is unlikely to pose a significant risk to an intruder in most reasonably foreseeable scenarios, largely because the total amount of radioactivity a well driller (or other intruder exposed to a small volume of waste) is exposed to is limited by the small amount of waste exhumed. However, as explained in Appendix B, an intruder who exhumes waste with a concentration significantly above the class limits (e.g., with a sum of fractions greater than 10) could incur a dose in excess of 5 millisieverts/year (mSv/yr) (500 millirem (mrem)/yr).

Table 1. Concentrations and Volumes of Waste Above Which Demonstrating Waste Homogeneity is Recommended

Sum of Fractions in Most Concentrated Influent Waste Stream	Annual Volume of Waste [m^3/yr (ft^3/yr)]	
	If Blended Product is Class A	If Blended Product is Class B or C
Less than 10 times the Class Limit	No Homogeneity Demonstration Recommended	No Homogeneity Demonstration Recommended
Between 10 and 100 times Class Limit	74 (2,600)	0.7 (25)
Greater than 100 times Class Limit	0.6 (21)	0.6 (21)

Mixing waste streams that each have a sum of fractions within a factor of 10 of the class limit does not need a specific demonstration of homogeneity, irrespective of the total volume of waste produced. This position is based on NRC calculations, described in Appendix B, that indicate that exhumation of a small volume of waste within 10 times the class limit, provided that the complete waste packages meet the class limit, does not present an excessive dose to an inadvertent intruder. The staff found that calculations considering exhumation of Class A waste at 100 years or Class C waste at 500 years produced similar results. Therefore, if the most concentrated waste stream in a mixture has a sum of fractions less than 10, the homogeneity of the blended product does not need to be verified.

At concentrations more than 10 times the class limit, an intruder who exhumes a small volume of waste from a hot spot could receive a dose greater than 5 mSv/yr (500 mrem/yr) even if the package as a whole meets the class limits. For example, consider a 0.04 m^3 (1.4 ft^3) hot spot with a sum of fractions of 100. If this hot spot is roughly spherical, an intruder using a 0.2 meter (m) (8 inch (in.)) well bore could intersect approximately 0.013 m^3 (0.47 ft^3) of the concentrated waste. In a well-drilling scenario in which cuttings are spread on the land surface (Appendix B), the dose to an intruder who exhumes this waste would be approximately 12 mSv/yr (1.2 rem/yr). As previously discussed, at a fixed sum of fractions, a larger package could accommodate a larger hot spot and a smaller package would limit the hot spot to a smaller volume, if the package is to meet the class limit. Considering the fractions of these hot spots an intruder could exhume with a 0.2 m (8 in.) well bore, the range of doses for packages ranging from internal volumes of 3 m^3 (100 ft^3) to 5 m^3 (180 ft^3) would range from approximately 10 mSv/yr (1 rem/yr) to 18 mSv/yr (1.8 rem/yr). Allowing some additional dose for the remaining waste in the waste column (i.e., outside of the hot spot), these doses are still expected to remain below 20 mSv/yr (2 rem/yr). In this dose range, the International Atomic Energy Agency (IAEA) recommends disposal is appropriate, but it also is appropriate to take steps to reduce the probability of the intruder's exposure to the waste (IAEA, 2011). Furthermore, because the potential consequence is not excessive, the staff finds it is not necessary to demonstrate the complete absence of any such hot spot to demonstrate compliance with the performance objective for intruder protection. That is, the staff finds it is sufficient to ensure such hot spots are infrequent to establish reasonable assurance (as required by 10 CFR § 61.40, "General Requirement") that the performance objective for intruder protection is satisfied.

Therefore, to limit the probability that an intruder will encounter such a hot spot, the NRC staff recommends measures to limit the number of these hot spots with concentrations between 10 and 100 times the class limit. To limit the frequency of hot spots, the staff proposes that licensees producing a significant quantity of blended waste from wastes in this concentration range test the homogeneity of the blended product. Specifically, the staff proposes that an appropriate volume limit beyond which it is appropriate to demonstrate waste homogeneity is 0.1 percent of the country's annual commercial (i.e., non-U.S. Department of Energy) volumes of the applicable class of waste (either A or B and C combined) disposed of in licensed facilities. Based on data from 2007 to 2008,[7] this limit equates to a volume of approximately 74 m^3 (2,600 ft^3) for Class A waste or 0.70 m^3 (24 ft^3) for Class B and C waste. This percentage was

[7] Waste volumes reported are from July 1, 2007, to June 30, 2008. Data obtained from the U.S. Department of Energy Manifest Information Management System (MIMS), http://mims.apps.em.doe.gov/.

chosen to limit the potential cumulative effect of many licensees blending small volumes of these concentrated wastes without demonstrating waste homogeneity. That is, if many licensees combine mixable wastes, the total volume of these mixtures in which homogeneity has not been demonstrated will still be a small fraction of waste produced annually in the applicable waste class. This measure is intended to limit the chance that an intruder will encounter such waste. If concentrations are not limited to less than a sum of fractions of 100 by the influent waste streams, the potential consequence of exhuming a poorly-mixed hot spot may be unacceptable, even if a package meets the classification limits. As a practical matter, only a very small amount of waste with a sum of fractions 100 or more times the class limit can be incorporated into a package that, on average, does meet the class limit. Although the NRC staff expects that this type of concentrated waste can be blended sufficiently to protect intruder safety, because of the potential consequence, the staff finds that it typically will be appropriate to verify the quality of blending through a specific demonstration of waste homogeneity. An exception can be made for volumes of waste so small that the total activity is limited. Specifically, production of less than 0.6 m^3/yr (21 ft^3/yr) of blended waste does not meet the threshold for a specific demonstration of homogeneity, irrespective of the concentrations of the influent waste streams.

4.2.2.2 *Demonstrating Homogeneity*

In cases in which it is appropriate to demonstrate waste homogeneity, the NRC staff recommends that a licensee demonstrate that the waste does not contain pockets larger than 0.15 m^3 (5 ft^3) with a sum of fractions greater than 10. In general, homogeneity demonstrations may be based on process knowledge, reasoned conclusions, or direct measurements (e.g., by samples or surveys). For example, demonstration that a blending process produces homogeneous waste may be based on knowledge about the influent waste streams, knowledge about the degree of mixing achieved in the blending process (e.g., by testing with physically similar but non-radioactive materials), or measurements taken at various points in processing (i.e., not necessarily measurements of individual waste containers). Direct measurements are not necessarily a preferable method for demonstrating waste homogeneity and, in some cases, may not be consistent with as low as is reasonably achievable (ALARA) principles if other methods of demonstrating homogeneity are available.

In the simplest case, if the inputs to a process are all known to have radionuclide concentrations (on a sum of fractions basis) less than 10 times the relevant classification limit, the waste may be considered homogeneous without any further consideration. For example, consider a processor blending waste with Class B radionuclide concentrations with lower activity waste to create Class A waste. If the higher activity waste stream has radionuclide concentrations within a factor of 10 of the Class A limit (i.e., a sum of fractions of 10 or less relative to the Class A limits), the activity does not meet the threshold for demonstrating waste homogeneity (Table 1). That is, no testing or demonstration is required to establish waste homogeneity.

In other cases, licensees may be able to rely on existing characterization programs for mixable wastes (e.g., programs designed to satisfy waste shipping requirements). For example, many wastes, including ion exchange resins, currently are shipped as “Low Specific Activity” (LSA) waste. To qualify as LSA waste, radioactivity must be demonstrated to be “distributed throughout” a waste or “essentially uniformly distributed” within a waste (see 10 CFR § 71.4, “Definitions”). These terms are described in the NRC guidance “Categorizing and Transporting

Low Specific Activity Materials and Surface Contaminated Objects" (NUREG-1608) (NRC, 1998), as originally described in IAEA guidance (IAEA, 1990). Specifically, this NRC and IAEA guidance indicates that radioactivity is "distributed throughout" a waste if the specific activity among 0.1 m^3 (3.5 ft^3) volumes of objects[8] or materials do not vary by more than a factor of 10. The guidance also indicates that radioactivity is "essentially uniformly distributed" in a waste if the specific activity among 0.1 m^3 (3.5 ft^3) volumes does not vary by more than a factor of three. These definitions, developed for transportation safety, are more restrictive than necessary to ensure protection against inadvertent intrusion because they are related to the average activity in the waste rather than the class limit. In addition, these definitions are based on slightly smaller volumes than considered in the recommended homogeneity criterion in this document (i.e., 0.1 m^3 [3.5 ft^3] as compared to 0.15 m^3 [5 ft^3]). Therefore, it is not necessary to demonstrate that waste may be considered LSA waste to demonstrate that it is homogeneous in the context of disposal. However, if a licensee has an existing program for a mixable waste to demonstrate that it may be shipped as LSA waste, it may be convenient for the licensee to rely on the existing program to demonstrate that the mixable waste is homogeneous in the context of disposal.

Practical methods for demonstrating that radioactivity is distributed throughout a waste or essentially uniformly distributed within a waste are described in NUREG-1608, Section 4.2.3. One of the methods, but not the only method, described in NUREG-1608 relies on compliance with the previous version of this BTP (NRC, 1995). The homogeneity guidance for mixable waste in this document is less restrictive than the corresponding guidance in the 1995 BTP (i.e., the factor of 10 rule). Thus, existing programs related to the homogeneity of mixable waste based on the 1995 BTP are sufficient (but not always necessary) to demonstrate that waste meets the homogeneity guidelines in this document.

Alternately, if it is preferable for a licensee to use guidance related to a class limit, rather than the average specific activity in a waste, a licensee could demonstrate that the waste does not contain pockets of 0.15 m^3 (5 ft^3) or larger that exceed a sum of fractions of 10. This test may be applied to either a package of mixable waste or a process. For example, a processor may demonstrate that a particular process reliably eliminates pockets of material of 0.15 m^3 (5 ft^3) or more with elevated concentrations. To demonstrate waste is reliably homogenized, the material used in the demonstration should be physically similar to the waste to be blended. In addition, the test inputs should have a similar or larger concentration difference than the intended influent waste streams. For example, if a cold test is performed, the ratio of the tracer concentrations in the influent streams (higher concentration to lower concentration) should be larger than the ratio of the sum of the fractions (higher concentration) in the wastes to be blended.

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[8] Although the definition of LSA-III in 10 CFR 71.4 indicates that it may apply to a "collection of solid objects," discrete objects pose concerns in the context of waste disposal that they do not pose during transportation. Specifically, an inadvertent intruder may carry away a discrete object exposed through intrusion (Appendix B). This risk is managed with restrictions on concentration averaging for discrete objects (Sections 4.3 - 4.5). Therefore, although meeting the LSA guidelines is an appropriate method of demonstrating that mixable waste is homogeneous, designation as an LSA waste does not indicate that a discrete object or collection of discrete objects is homogeneous in the context of waste classification.

If direct measurements are used, appropriate methods to demonstrate waste homogeneity depend on the identities and average concentrations of classification-controlling radionuclides[9] in the waste. If waste classification is controlled by gamma-emitting radionuclides or radionuclides that may be reliably scaled to gamma-emitting radionuclides, it may be practical to demonstrate waste homogeneity with surveys.

The appropriate methods to demonstrate that certain equipment and processes generate homogeneous waste may depend on specific process features. For example, if continuous surveys can be performed while waste is mixed (e.g., if a survey can be performed on a pipe as waste is recirculated) it may be practical to survey a significant fraction of the volume of the waste to determine if any detectable fraction has a concentration exceeding 10 times the concentration limit. In this case, the detectable fraction should correspond to approximately 0.15 m^3 (5 ft^3) of waste to demonstrate homogeneity. Whether an elevated concentration in this quantity of waste can be detected may depend on the configuration of equipment (e.g., piping diameter) and process parameters (e.g., flow rate).

4.2.3 *Classification of Homogeneous Waste*

As indicated in the introduction of this section, the classification of containers of homogeneous waste may be based on the total radionuclide activity in the container divided by the waste volume (or mass, as appropriate) in the waste container. The NRC staff assumes that licensees will manage the uncertainty in waste classification calculations with existing quality assurance programs for waste classification (see Section 4.7). In general, the acceptable uncertainty in the average concentration of classification-controlling radionuclides depends on how close the sum of fractions is to the classification limit. The waste classification BTP (NRC, 1983) indicates that more sophisticated waste classification programs should be used for waste for which minor process variations may cause a change in waste classification. In accordance with this general principle, more sophisticated waste classification programs should be used for processes in which one of the influents is much more concentrated than the intended classification of the final product.

4.3 Classifying a Mixture of Activated Metals, Contaminated Materials or Cartridge Filters

This section provides guidance on the classification of a container of multiple items of activated metals, or contaminated materials, or cartridge filters. Activated metals include neutron-activated materials or metals, or components incorporating radioactivity in their design. This position on classifying a container of similar waste type items includes a number of criteria to ensure that individual hot spots (in this context, higher activity items) do not compromise the safety of an inadvertent intruder. These criteria are: 1) if the activity is less than 37 MBq (1 mCi) then the entire mixture can be concentration averaged with no issue; 2) if an individual item is greater than 37 MBq (1 mCi), then a licensee can use conservative classification (classification is based on the highest classification of any individual item in the mixture), or concentration average after tests are applied to remove any hot spots. These criteria for identifying and removing hot spots are detailed in the next three subsections. The positions in this section do not apply to homogeneous waste types, which are addressed in Section 4.2.

[9] See Glossary in Appendix A for definition.

For this position, if a larger component is cut into pieces for operational considerations (e.g., packaging for transportation), the activities may be averaged over the volume (or mass, as appropriate) of the original larger component, provided the pieces pass the Table A and Table B criteria, and provided the individual pieces are all placed in the same container. Passing the Table Table A criteria means that no individual piece: (1) has a volume less than 280 cubic centimeters (cc) (0.01 ft^3) and (2) has primary gamma activity that exceeds the values shown in Table A. Passing the Table B criteria means that no individual piece has activity that exceeds the values shown in Table B. Both the Table A and Table B tests are explained more fully in the following sections.

If a waste container or liner contains pieces from more than one component, it is the characteristics of the original component that are evaluated using the criteria described in Sections 4.3.1 through 4.3.3. As a simple example, assume that a larger activated metal component is cut into four individual pieces for operational considerations and those four individual pieces each pass the Table A and Table B tests. The four pieces are then combined with five more pieces of activated metal in a single container. The four pieces (from the single larger component) are assessed as a single piece, along with the five additional pieces (assessed as six pieces total -- one large component plus five additional pieces).

In classifying a mixture of pieces of activated metals, contaminated materials, or cartridge filters, the first step is to determine if each item in the mixture has an activity less than 37 MBq (1 mCi) (node E). If so, then the entire mixture may be concentration-averaged over the volume or mass of the waste.

For mixtures where one or more items have an activity greater than 37 MBq (1 mCi), the classification guidance is contained in Sections 4.3.1 through 4.3.3 and nodes F through K of Figure 1. The detailed guidance contained in Sections 4.3.1 through 4.3.3 is summarized below.

The first step in classifying a mixture of pieces, where one or more items have an activity greater than 37 MBq (1 mCi), is to determine whether to conservatively classify the mixture based on the piece in the mixture with the highest classification (Section 4.3.1 and node F). If the mixture is not conservatively classified, then the mixture can be concentration averaged for classification (by dividing the summed nuclides by the summed volumes (or masses), so long as radiological "hot spots"[10] are identified and removed from the mixture. Depending on which nuclides control the classification of the mixture, three or possibly four tests are used to identify hot spots for removal:

- The first test is whether an individual item is both small (less than 280 cc (0.01 ft^3)) and contains radioactivity for specific radionuclides greater than the Table A values (Section 4.3.2 and node G). This test is should always be applied to all pieces in a mixture.
- In the second test (Section 4.3.2 and node I), the activity of each primary gamma-emitting nuclide in each piece should not exceed two times the classification limit for that nuclide for

[10] These terms: "hot spots," "nuclide(s) of concern," "primary gamma-emitting nuclides" and "classification-controlling nuclide(s)" have specific meanings which are presented in the Appendix A Glossary.

the classification of the mixture. The second test is only applied if the primary gamma-emitting nuclides control the classification of the mixture (node H).

- The third test is whether the non-primary gamma emitters in an individual piece exceed the radioactivity levels in Table B (Section 4.3.3 and node J) and should always be applied to individual pieces.
- The fourth test (Section 4.3.3 and node K) is to ensure that each nuclide(s) of concern in each individual piece is less than 10 times the classification limit for that nuclide for the classification of the mixture. This test should always be applied

The conservative classification option and the four tests for hot spots are discussed in the following sections.

4.3.1 *Conservative Classification Based on Highest Individual Contributor*

If items in the mixture have an activity greater than 37 MBq (1 mCi) (node E), then the next step (node F) is to determine whether to conservatively classify the mixture according to the contributor item in the mixture with the highest classification. One may always classify a mixture conservatively based on the highest classification of any individual item in the mixture. Thus, if a mixture of items in a waste container includes a single item classified as Class C based on 10 CFR § 61.55, and the remaining items are classified as Class A, the entire waste container may be conservatively classified as Class C LLRW. Using the example described in Section 4.3 above, the conservative classification option is assessed as if there were six pieces in the container (one large component plus five additional pieces), and the option would not be applied to the nine individual pieces that actually exist in the container.

If the licensee does not conservatively classify the mixture of pieces as described here, then the pieces in the mixture can be concentration averaged after the removal of radiological hot spots. Sections 4.3.2 and 4.3.3 describe the screening criteria for identifying and removing radiological hot spots before concentration averaging when classifying mixtures of activated metals, contaminated materials, or cartridge filters. Appendix B provides justification for the screening criteria presented in Sections 4.3.2 and 4.3.3.

4.3.2 *Averaging Involving Primary Gamma Emitters*

As used in this BTP, the primary gamma-emitting nuclides are Co-60, Nb-94, and Cs-137/Ba-137m. If (1) the volume of any item in the mixture is less than 280 cc (0.01 ft^3), and (2) the activity of that item exceeds the values shown in Table A (node G), the item should be removed and treated as an individual item per Figure 2. Such items are similar to sealed radioactive sources and should be managed individually.

Table A. Activity Levels of Primary Gamma Emitters in Individual Items Requiring Piecemeal Consideration in Classification Determinations

Nuclide	Waste Classified as Class A	Waste Classified as Class B	Waste Classified as Class C
Co-60	>5.2 TBq (140 Ci)	No limit.	No limit.
Nb-94	>37 MBq (1 mCi)	>37 MBq (1 mCi)	>37 MBq (1 mCi)
Cs-137/Ba-137m	>266 MBq (7.2 mCi)	> 27 GBq (0.72 Ci)	>4.8 TBq (130 Ci)

After Table A items have been removed (the first test), the remaining mixture is further evaluated for gamma-emitting hot spots (the second test). If the primary gamma-emitting nuclides are the classification-controlling nuclide(s) (i.e., if they control the classification of the mixture), then the specific activity of each primary gamma-emitting nuclides in each individual piece, must be less than two times the classification limit for that nuclide (nodes H and I). This is the factor of two rule. As a simple example, if there are multiple pieces of activated metal in a container and Nb-94 is the only nuclide of concern, and the classification of the mixture is Class A, then no individual item should have a Nb-94 concentration greater than 1.5 GBq/m^3 (0.04 Ci/m^3) (which is two times the Class A limit for Nb-94). This factor of two rule does not apply if the classification of the mixture, as a result of radionuclides other than the primary gamma emitters, is higher than the classification derived from the primary gamma emitters. Also, the factor of two rule does not apply to individual pieces if the primary gamma-emitting nuclide activity is less than 37 MBq (1 mCi) in each piece.

4.3.3 *Averaging Involving Nuclides Other Than Primary Gamma Emitters*

As used in this BTP, nuclides other than primary gamma emitters are all 10 CFR § 61.55 tabulated radionuclides in the disposal container, other than Co-60, Nb-94, or Cs-137/Ba-137m. If any item in the mixture exceeds the values shown in Table B (node J), these items should be removed and treated as individual items per Figure 2. This is the third test for the mixture. The constraints in this table prevent averaging of items across more than one waste class.

Table B. Activity Levels of Radionuclides other than Primary Gamma Emitters in Individual Items Components Requiring Their Piecemeal Consideration in Classification Determinations

Nuclide*	**For Waste Classified as Class A or B**	**For Waste Classified as Class C**
H-3	>0.3 TBq (8 Ci)	N.A.
C-14	>0.04 TBq (1 Ci)	>0.4 TBq (10 Ci)
Ni-59	>0.15 TBq (4 Ci)	>1.5 TBq (40 Ci)
Ni-63	>0.26 TBq (7 Ci)	>55 TBq (1500 Ci)
Alpha emitting TRU with ½ life > 5 years (excl. Pu-241 and Cm-242)	>111 MBq (3 mCi)	>1.1 GBq (30 mCi)

* Other nuclides listed in the tables in 10 CFR § 61.55 are not expected to be of importance in determining waste classification.

The remaining mixture is further evaluated for radiological hot spots using the following criterion (node K). The specific activity of each nuclide(s) of concern in each individual piece should be less than 10 times the classification limit for that nuclide for the classification of the mixture (this is the fourth test). A nuclide(s) of concern is a nuclide(s) in the waste in concentrations greater than 1 percent of the concentration of that nuclide listed in Table 1 of 10 CFR Part 61, or 1 percent of the applicable class-dependent concentration of that nuclide in Table 2 of 10 CFR Part 61, Column 2 or 3. This is the factor of 10 rule.

Items whose specific activity exceeds the factor of 10 rule above should be removed and managed as individual items per Figure 2. If the concentrations of all remaining nuclides in all remaining pieces are below the factor of 10 rule, the classification of the mixture may be based on the volumetric- or weight-averaged concentrations of the combined materials.

Section 4.4, as outlined in Figure 2, provides guidance for classifying individual items including solidified and absorbed liquids.

4.3.4 *Cartridge Filters as Homogeneous Waste*

Cartridge filters may not always pose the same risk to an inadvertent intruder as individual items of waste such as activated metals and sealed sources. These latter waste types may cause an inadvertent intruder to receive an unacceptable radiation dose from the scenarios postulated in Appendix B, and these scenarios are the basis for the averaging constraints above. Cartridge filters, however, may be physically and radiologically different from activated metals and sealed sources and therefore be treated as homogeneous waste in some cases when a justification can be provided, for the following reasons. First, radioactivity in filters is largely contained as solid particles on the filter media (i.e., it is not chemically bound to the filter media). Therefore, it may be dislodged by an intruder, thus reducing the radiation exposure. Second, some cartridge filters have housings enclosing the filter media that are perforated to allow for fluid flow. These perforations also would allow for spillage of radioactive material if the filters were to be handled by an inadvertent intruder. Finally, cartridge filters typically do not contain long-lived gamma radioactivity that would pose a hazard to the intruder if they were considered to be discrete items. With regards to the primary gamma emitters that pose a potential hazard to an intruder, much of the Co-60 may have decayed by 100 years after the disposal facility closes; the Cs-137 concentrations and amounts on filters are low because the radionuclide is soluble and filters capture solid materials, and Nb-94 is principally contained in activated metals.

Licensees may therefore dispose of cartridge filters as homogeneous waste, provided an analysis is conducted, documented, and made available for inspection. The analysis should examine the following:

- The specific cartridge filters covered by the analysis, i.e., the design and manufacturer of the filter and the reactor system it is employed in.

- The physical characteristics of the filter design that justify not treating it as a discrete waste, specifically:

    - the design characteristics of the filter that would enable radioactivity on the filter not to remain within the filter during an intrusion event, such as perforations in the filter housing; and

    - the filter medium is non-metallic and expected to degrade during disposal and before intrusion occurs; and

- A history of the activity levels of primary gamma emitters in the filters covered by the analysis sufficient to demonstrate that the activity of the primary gamma emitters for filters is within the Table A values in this BTP for the appropriate waste class and that the concentrations of non-primary gamma emitters on filters is not greater-than-Class C. These values should be initially determined and periodically confirmed through measurements.

Individual cartridge filters that cannot be justified as homogeneous waste in accordance with the above are subject to the averaging constraints for individual items in this BTP.

4.4 Classifying Individual Items

Figure 2 provides guidance for classifying individual items including solidified and absorbed liquids. The classification of solidified liquid wastes (node L) should be based on the volumetric- or weight-averaged concentration of the final waste form.[11] The classification of an absorbed liquid (node M) should be based on the original volume or weight of the liquid.

For individual items other than those originating from liquids, the individual items are first characterized in accordance with 10 CFR § 61.55 (node N). Individual items exceeding the Class B or C characteristics may be considered for encapsulation, following the encapsulation guidance in Section 4.5 below. If an item is encapsulated, the concentration may be averaged over the volume or weight of the final waste form, as described below, for the purposes of classification (node O).

4.5 Encapsulation of Sealed Sources and Other Solid Low-Level Radioactive Wastes

Encapsulation can mitigate waste dispersion, provide additional shielding to limit external radiation, and satisfy the stability requirement of 10 CFR § 61.56(b) and the technical requirements for land disposal facilities of 10 CFR § 61.52(a). However, the amount of credit allowed for encapsulation should be limited so that extreme measures cannot be taken solely for the purposes of lowering the waste classification. To limit extremely high-activity point sources in the disposal site that could pose an unacceptable risk to an inadvertent intruder, the staff has developed generally acceptable values for minimum and maximum encapsulated waste volume and mass, nuclide activities, and external radiation levels. These generally acceptable bounding conditions are as follows:

- The minimum solid volume or mass used to encapsulate should be sufficient to make handling the radioactive waste by an inadvertent intruder prohibitively difficult. The size or weight of the encapsulated radiation source should be large enough to preclude movement without the assistance of mechanical equipment.

- For determining the classification of an encapsulated item (or multiple items in a single container), the maximum volume or mass should be 0.2 m^3 or 500 kg (approximately 55 gallon or 1100 pounds). For physically encapsulating a single item, the volumes and masses may be larger than 0.2 m^3 or 500 kg (approximately 55 gallon or 1,100 pounds) to allow for disposal of the item (such as a sealed source) in its shielded housing and/or source device. The shape of the final encapsulated package does not have to be a cylinder.

- Multiple items (such as sealed sources) may be encapsulated together in a single 0.2 m^3 (approximately 55 gallon) container, so long as the final encapsulated package meets the other criteria described herein.

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[11] For solidification of liquid wastes, extreme measures to lower the waste classification should not be employed. The added materials should be generally sufficient to solidify the waste.

- Licensees may use larger volumes for averaging of encapsulated waste previously approved by NRC in topical reports, and subject to the use of the process/material covered by the report and the specific conditions in the approval

Other guidance for encapsulation is as follows:

- The maximum amount of any radionuclide that should be encapsulated in a single 0.2 m^3 (approximately 55 gallon) disposal container should not cause the average concentration in the container to exceed the maximum concentration limits for Class C waste, as defined in Tables 1 and 2 of 10 CFR § 61.55, when averaged over the waste and the encapsulating media. For example, a Ni-59 source should not exceed 1.5 terabecquerel (TBq) (40 Ci) and a Pu-239 source should not exceed 1.1 GBq (30 mCi).

- The maximum gamma-emitting radioactivity (e.g., from Cs-137/Ba-137m, Nb-94 and Co-60) acceptable for encapsulation is that which would result in a dose rate of less than 0.2 µSv/hour (hr) (0.02 mrem/hr) on the surface of the encapsulated package after decaying for 500 years. Furthermore, the maximum Cs-137/Ba-137m gamma activity acceptable for encapsulation in a single disposal package is 266 MBq (7.2 mCi) for Class A disposal, 27 GBq (0.72 Ci) for Class B disposal and 4.8 TBq (130 Ci) for Class C disposal. The maximum Nb-94 activity acceptable for encapsulation for Class A, B, or C disposal is 37 MBq (1 mCi). There is a 5.2 TBq (140 Ci) limit for Class A disposal of Co-60 and no activity limit for Class B or C disposal of encapsulated Co-60 sources.

- In all cases in which an item is (or items are) encapsulated, written procedures should be established to ensure that the radiation source(s) is reasonably centered within the encapsulating media.

4.6 Determining the Volume of the Waste

The May 1983 technical position provides the NRC's guidance for determining nuclide concentrations. Table C below provides guidance for determining waste volumes.

Table C. Volume and Mass for Determination of Concentration

Waste Type	Allowable Classification Volume or Mass
Contaminated trash or soil or DAW	Reasonable fill volume of container or mass of waste (<10% void)*
Solidified liquids	Volume or mass of solidified mass
Solidified ion-exchange resins	Volume or mass of solidified mass**
Absorbed liquids	Volume or mass of original liquid
Dewatered ion-exchange resins in High-Integrity Containers (HICs) or liners	Displaced (bulk) volume of waste (interstitial space may be included) or dewatered mass of ion-exchange resins

Filter cartridges in HICs or liners	Envelope volume or mass of filters* The envelope volume is the volume obtained using the outer dimensions of the filter (interstitial volume is included in the envelope volume)
Activated components, components containing radioactivity in their design, or contaminated materials	Full density volume (major void volumes subtracted from envelope volume) or mass of components*
Encapsulated filter cartridges or sealed sources	Volume or mass of solidified mass when encapsulated in accordance with the guidance provided in this Position
* Mixtures of waste streams subject to additional guidance defined in Section 4.2. **If homogeneity is maintained in the solidified mass.	
--For wastes stabilized by emplacement within High Integrity Containers (HICs), the volume or weight used to determine classification should be based on the displaced volume or weight of the waste itself, rather than the gross volume or weight of the HIC. --For any of the above wastes that include mixing of non-radioactive constituents with the LLRW (such as for solidification, encapsulation, or additives used in thermal processing), non-radioactive materials added to the mixture should have a purpose other than reducing the waste class, such as waste stabilization or process control. Consistent with other provisions in this BTP, extreme measures to lower the waste classification should be avoided.	

4.7 Quality Assurance Program

In accordance with Appendix G of 10 CFR Part 20, "Requirements for Transfers of Low-Level Radioactive Waste Intended for Dispersal at Licensed Land Disposal Facilities and Manifests," the licensee classifying the waste must have in place a quality assurance program to ensure compliance with the waste classification provisions of 10 CFR § 61.55. As part of this quality assurance program, if the classification of a mixture is based on the volumetric- or weight-averaged nuclide concentration of a mixture, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analysis. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the mixing was undertaken consistent with the guidance found in this BTP.

4.8 Alternative Requirements for Waste Classification (10 CFR § 61.58)

Under 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 the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in subpart C of 10 Part 61, "Performance objectives." The waste classification requirements for near-surface disposal are contained in 10 CFR § 61.55. That section identifies specific radionuclides and concentrations for determining the class of waste (A, B, C, or greater-than-class C). Classification involves consideration of both long-lived radionuclides, whose potential hazard will persist long after such precautions such as institutional controls, improved waste form, and deeper disposal have ceased to be effective, and shorter-lived radionuclides, for which such precautions can be effective. Classification is used in part to determine whether the stability requirements in 10 CFR § 61.56, "Waste characteristics," are applicable. Stability is the ability of waste to maintain gross physical properties and identity over 300 years, and one of its functions is to limit exposures to inadvertent intruders. The stability requirements in 10 CFR § 61.56 apply only to Classes B and C waste (per 10 CFR § 61.52(a)ii and 10 CFR § 61.52(a)iii respectively) and stabilized Class A (per 10 CFR § 61.52(a)(i)).

In 10 CFR § 61.58, the NRC allows the flexibility to establish alternate requirements for waste classification and characteristics when justified by site-specific conditions and the unique characteristics of the waste. These alternative provisions would not affect the generic waste classifications established in 10 CFR § 61.55. Thus, the radionuclide concentrations in the waste define the class of the waste in accordance with the 10 CFR § 61.55 waste classification tables. If it can be demonstrated that the performance objectives of 10 CFR Part 61 would be met, then, for example, waste that contains Class B concentrations of radionuclides could be authorized for disposal in a Class A disposal cell using 10 CFR § 61.58.

4.9 Alternative Approaches for Averaging

The approaches in Sections 4.2 – 4.6 of this BTP may be used by generators and waste processors to classify LLRW for shipment to a licensed disposal site. Most of the approaches are generic and apply to all LLRW disposal sites. Other methods may be used by licensees, however, and the following guidance discusses considerations for site- and waste-specific methods and other approaches to intruder protection that could potentially justify concentration averaging positions different from those in this BTP. Other approaches different from those below could also be proposed by licensees for review by the disposal facility regulator.

4.9.1 *Use of Site-Specific Intruder Assessments*

Concentration averaging approaches, including approaches to demonstrating the homogeneity of mixable waste, based on site-specific features, and different from those in Sections 4.2 - 4.6, may be proposed by disposal facility licensees for approval by the regulatory authority. The proposal should contain the following types of information, as applicable:

- A detailed description of the waste form(s) covered by the alternative averaging approach.
- An identification of the BTP's existing position for which an alternative is requested.
- For proposals based on inadvertent intruder exposure scenarios different from those in the BTP, a discussion of how they were selected should be provided. The following criteria are applicable:
    - The scenario should be based on the intruder performing reasonably foreseeable, but conservative activities, consistent with regional social customs, well drilling, excavation and construction practices, and the regional environmental conditions projected for the time that intrusion is to occur.

- The time period for intrusion should be appropriate for the class of the waste (e.g., 100 or 300 or 500 years) as discussed in 10 CFR § 61.7(b). In some cases, licensees may propose averaging approaches based on depth of burial, or the use of intruder barriers or durable waste forms or containers.

- An overview of the proposed alternative provision (e.g., depth of burial or other factors), and how the alternative provision protects the intruder.

- A description of site characteristics pertinent to the proposal.

- An analysis of the effects of degradation on packaging and engineered barriers over the period that the waste remains hazardous to an intruder.

Several NRC guidance documents may be useful in addressing the above considerations. NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," (NRC 2007) provides guidance for site-specific intruder assessments that may be of use to licensees preparing proposals, as it involves waste disposal using the performance objectives in 10 CFR Part 61, Subpart C. NUREG-1757, Vol. 2, "Consolidated NMSS Decommissioning Guidance: Characterization, Survey and Determination of Radiological Criteria," (NRC 2006) provides guidance on the evaluation of engineered barriers used in site decommissioning. If similar barriers are used in land disposal of LLRW, then NUREG-1757, Vol. 2 may be useful. Finally, NRC staff's "Summary of Existing Guidance That May Be Relevant for Reviewing Performance Assessments Supporting Disposal of Unique Wastes Streams" also addresses site-specific performance assessments. (NRC 2010).

If the radiological hazard will persist beyond time frames used for the 10 CFR § 61.55 waste classification tables (such as for disposal of large quantities of depleted uranium), licensees should consider intruder activities typical of generic scenarios (e.g., NUREG-0782, (NRC 1981), NUREG-0945 (NRC 1982), and NUREG/CR-4370 (NRC 1986)) that are plausible within the compliance period considering the capabilities of intruder barriers and the natural evolution of site characteristics. Use of generic scenarios limits excessive speculation about future human activity.

4.9.2 *Encapsulation of Sealed Sources*

The position on encapsulation in Section 4.5 is considered generally suitable for all LLRW disposal facilities licensed under 10 CFR Part 61, or the equivalent Agreement State regulation. Other provisions may be authorized on a specific basis for the encapsulation of items if, after an evaluation of the specific characteristics of the waste form, the disposal site, and the method of disposal, there is reasonable assurance of compliance with the inadvertent intruder performance objective in 10 CFR § 61.42.

As long as the proposed alternative provisions for an encapsulated item meets the 10 CFR § 61.55 waste classification requirements, licensees do not need to seek authorization under 10 CFR § 61.58 or request an exemption. For example, if a licensee's proposal is determined to justify disposal of a 33 TBq (900 Ci) Cs-137 sealed source in a tungsten shielded cask buried 12 m (40 ft) deep, in a 0.5 m^3 (18 ft^3) encapsulated waste form, a 10 CFR § 61.58 authorization or an exemption is not necessary, because 33 TBq (900 Ci) of Cs-137 in 0.5 m^3 (18 ft^3) is well within the 10 CFR § 61.55 Class C limits of 4,600 Ci/m^3 (4.8 TBq/ft^3) for Cs-137. Alternative encapsulation proposals for encapsulating individual items that would exceed the 10 CFR § 61.55 waste classification limits would require use of 10 CFR § 61.58 or an exemption.

Because of sealed source accidents, the NRC is concerned that highly radioactive items might survive for long time periods in a disposal facility and be unrecognized by the intruder as hazardous. Given this concern, the BTP used a gamma source carry-away scenario to establish the 4.8 TBq (130 Ci) limit for Class C disposal of Cs-137 sealed sources at the time of disposal, and other limits. The source carry-away scenario is based on the assumption that in the future, the encapsulating media has fallen away, and a sealed source is exposed at the land surface by a civil works project. It is further assumed that the intruder does not recognize the hazard and places the sealed source (an old and interesting piece of metal) in a pocket for 4 hours before taking it home. The full details of this scenario are presented in Appendix B.

Alternative proposals should provide reasonable assurance that the above referenced scenario is highly unlikely, so long as the source strength exceeds the criteria set in this position (i.e., 4.8 TBq (130 Ci) of Cs-137), and that another scenario is appropriate. Factors that could provide reasonable assurance that the gamma source-carry-away scenario is not credible for a specific disposal configuration (site and waste form) include, but are not limited to:

a) disposal of the item (e.g., a sealed source) in a robust and long-lived case that cannot be opened easily in the field (the entire package would still require encapsulation), and;

b) disposal of the encapsulated item at depths greater than 10 m (33 ft), with evidence that the depth of burial will be maintained for the period that the hazard exists.

In preparing a proposal that justifies a different approach, the proposal should contain the following types of information:

- a detailed description of the item(s) (e.g., sealed source(s)).
- a review of the BTP's existing position on encapsulation.
- an overview of the proposed alternative provision (e.g., depth of burial and/or other factors), and how the alternative provision protects the intruder.
- a description of site characteristics pertinent to the proposal.
- a description of any source containing devices and the encapsulating media.
- an analysis of the effects of degradation on packaging and engineered barriers over the period that the item remains hazardous to an intruder.

4.9.3 *Activated Metals and Contaminated Materials*

Activated metals and contaminated materials are subject to the averaging constraints in Section 4.3 of this position. These additional constraints are based on the premise that these types of items will not become soil-like within the time frame that they are hazardous. Stainless steel, for example, would be resistant to structural degradation and may be intact at the time that an intruder is postulated. Thus, an intruder could unknowingly be exposed to intact items that would result in a radiation exposure higher than if the items had become soil-like. If a licensee can demonstrate that either specific types of activated metals or contaminated materials become soil-like at the time of intrusion, this could be a basis for considering them to be mixable wastes. There is a wide range of materials, configurations, and designs for these items, and while these waste types generally should be considered as individual items in classification, some could potentially be classified as homogeneous waste. Justifications for treating items as homogeneous wastes, instead of individual items, should be reviewed and approved by the appropriate regulator. It is expected that a characterization of the disposal environment (e.g., groundwater characteristics, infiltration through the cover of the facility to contact the waste) and the corrosion rate of the activated metal or contaminated materials in this environment would be the key considerations in justifying this alternative approach.

4.9.4 *Considering the Likelihood of Intrusion*

Inadvertent intrusion is only expected if required active controls and passive controls (e.g., markers and barriers) and societal memory of the site are lost. This makes inadvertent intrusion unlikely, but possible, especially as time passes after closure of the disposal facility. However, there is no scientific basis for quantitatively predicting the nature or probability of a future human activity (NAS, 1995 and ICRP, 1998, paragraph 62). Therefore, an inadvertent intruder assessment typically does not consider a probability or likelihood of less than one of the inadvertent intrusion occurring. Rather, the assessment assumes reasonably conservative scenarios that could occur and evaluates the radiological consequences that could be experienced by individuals who might actually intrude onto the disposal site if active and passive controls and societal memory were lost (NCRP, 2005; IAEA, 2008).

Therefore, an intruder assessment typically is based on the assumption that the intruder directly contacts the disposed waste. This assumption sometimes is characterized as an assumption that the probability of intrusion is one. While it is accurate to say that intrusion analyses typically result in estimates of consequences (i.e., dose) rather than risk (i.e., dose multiplied by probability), it would be inaccurate to say the staff assumes intrusion will occur. Because it is not possible to make precise estimates of the probability of intrusion, the likelihood of intrusion is acknowledged implicitly in the 5 mSv/yr (500 mrem/yr) dose limit used for intruder protection. For example, NRC has previously indicated that it is appropriate to use an intruder dose limit of 5 mSv/yr (500 mrem/yr) instead of 1 mSv/yr (100 mrem/yr), the public dose limit in 10 CFR Part 20, because intrusion is a “hypothetical” event that may not occur (NRC, 1994). This higher limit essentially provides for a 20 percent probability of intrusion. Furthermore, the 5 mSv/yr (500 mrem/yr) limit is a factor of 20 greater than the 0.25 mSv/yr (25 mrem/yr) limit established in 10 CFR § 61.41 for protection of the general population from releases of radioactivity. This difference is largely attributable to the difference between the hypothetical nature of intrusion and the more likely possibility of exposure to small off-site releases, implying a 5 percent probability of intrusion. In addition, the inaccessibility of Class C waste to intruders was explicitly considered in establishing the Class C limits in 10 CFR § 61.55, further reducing the implied probability of intrusion into Class C waste.

In some circumstances, the likelihood of intrusion might be considered in justifying the selection of scenarios different from those used in this BTP. As an example, construction of an exploratory water well could be considered as possible, and a domestic drinking water well very unlikely, in areas without viable sources of groundwater. This is an example of a site-specific approach a licensee could consider in submitting a justification for concentration averaging methods different from those described in this BTP.

Notwithstanding the difficulty in quantitatively predicting future human activities, DOE's Order 435.1, "Radioactive Waste Management," allows for consideration of probability of intrusion. Its use of this provision has been limited, according to DOE, and has been based, in part, on the government's extended, long-term control of DOE sites, a factor that may not be available for commercial disposal facilities.

4.9.5 *Large Components*

Section 4.5 of this BTP on encapsulation and volume for averaging addresses averaging over containers of radioactive waste, such as a 0.2 m^3 (~55 gallon) drum. Other averaging volumes may be acceptable, however, and can be approved on a case-by-case basis. For example, regulators have approved disposal of large reactor components, such as reactor vessels with highly radioactive internal hardware grouted into the vessel cavity using averaging approaches unique to the waste types involved. In 1998, the State of Washington authorized the Portland Gas and Electric Co. to dispose of the Trojan nuclear plant reactor vessel with components grouted into the vessel and averaged over the volume of the vessel (Washington Department of Health, 1998). This approval and its disposition of technical and safety issues can be used as a model for other similar types of disposals.

4.9.6 *Time of Intrusion into Mixable Waste*

As described in Section 4.2.2 and Appendix B, both the threshold for homogeneity testing and the recommended criterion for demonstrating waste homogeneity are based on the potential dose to an individual who inadvertently exhumes waste from a hot spot in mixable waste. This analysis was conducted assuming an intruder drills into Class A waste at 100 years or Class C waste at 500 years. In practice, many Class A wastes are disposed of with robust engineered intruder barriers. If a Class A barrier meets the requirements of 10 CFR § 61.7(b)(5) for Class C waste, then it may be appropriate to consider intrusion at 500 years instead of 100 years, even if the waste is Class A waste. Depending on the nature of the barrier and the drilling technique, barriers that meet the requirements of 10 CFR § 61.7(b)(5) could preclude drilling scenarios during the lifetime of the engineered barrier and it may be appropriate to consider the effects of the barrier on the timing of possible inadvertent intrusion.

If the radionuclides of concern in a waste are primarily short-lived, a licensee may be able to demonstrate that, at the time of the earliest reasonably foreseeable opportunity for inadvertent intrusion, enough radioactive decay has taken place to make the waste homogeneous. That is, a licensee may be able to demonstrate that the additional decay time[12] beyond 100 years (the time of intrusion typically assumed for Class A waste) is sufficient to eliminate the potential for hot spots with a sum of fractions greater than 10. This demonstration would suffice as a demonstration of homogeneity in the context of this BTP, and no further demonstration of homogeneity is recommended.

This alternative approach is not likely to be useful if the waste classification is controlled by long-lived radionuclides. However, licensees are encouraged to consider this approach for wastes with short-lived radionuclides of concern disposed of with robust barriers to intrusion that

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[12] The licensee should consider the additional decay time beyond 100 years rather than then entire time over which the intrusion barrier is assumed to be effective because the BTP Table 1 values for Class A waste already include consideration of radioactive decay to 100 years.

could preclude drilling scenarios beyond the end of institutional controls. Direct measurements to demonstrate the homogeneity of these wastes are likely to be unnecessary as well as counter to efforts to minimize worker dose in accordance with ALARA principles if a reasoned argument based on barriers to intrusion would demonstrate homogeneity.

4.10 Implementation

This BTP describes, and makes available to the NRC licensees, Agreement States, and the public, methods that the NRC believes may be acceptable for implementing specific parts of the Commission's regulations. The positions in this document are not intended as substitutes for regulations, and compliance with them is not required. Applicants and licensees may use the information in this BTP when developing applications for initial licenses, amendments to licenses, or requests for NRC regulatory approval. Licensees may use the information in this BTP for actions that do not require prior NRC review and approval. Licensees also may use the information in this BTP to assist in attempting to resolve regulatory or inspection issues. Current licensees may continue to use the previous guidance found acceptable for complying with specific portions of the regulations as part of their license approval process.

In addition to the guidance in this BTP, licensees that ship waste for disposal in a 10 CFR Part 61 or Agreement State equivalent facility should ensure that the waste meets the concentration averaging provisions in the disposal facility license, if any, or separate waste acceptance criteria. Where there are conflicts with this guidance, the disposal facility license conditions are controlling.

5 References

International Atomic Energy Agency (IAEA), "The Radiological Accident in Goiania," Publication 815, Vienna, Austria, 1988.

IAEA, "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material," 1985 Edition (as amended in 1990), Safety Series No.37, International Atomic Energy Agency, Vienna, Austria, 1990.

IAEA, "Draft Safety Case and Safety Assessment for Radioactive Waste Disposal," Safety Guide DS 355, Vienna, Austria, 2008.

IAEA, "Disposal of Radioactive Waste Specific Safety Requirements," IAEA Safety Standards Series SSR-5, 2011.

National Academy of Sciences (NAS), "Technical Bases for Yucca Mountain Standards," National Academy Press, Washington, D.C., 1995.

International Commission on Radiological Protection (ICRP), "Annuals of the ICRP Publication 81, radiation protection recommendations as applied to the disposal of long-lived solid radioactive waste," Volume 28, No. 4, 1998.

National Council on Radiation Protection and Measurements (NRCP), "Performance Assessment of Near-Surface Facilities for Disposal of Low-Level Radioactive Waste," Recommendations of the National Council of Radiation Protection and Measurements, Bethesda, MD, NCRP Report No. 152, December 31, 2005.

U.S. Nuclear Regulatory Commission (NRC), “Draft Environmental Impact Statement on 10 CFR Part 61, ‘Licensing Requirements for Land Disposal of Radioactive Waste’,” NUREG-0782, September 1981. (ADAMS Accession No. ML062210362).

NRC, “Final Environmental Impact Statement on 10 CFR Part 61 ‘Licensing Requirements for Land Disposal of Radioactive Waste’,” NUREG-0945, November 1982. (ADAMS Accession Nos. ML052590184, ML052920727, ML052590187).

NRC, “Low Level Waste Licensing Branch Technical Papers on Radioactive Waste Classification and Waste Form; Availability,” *Federal Register,* 48 FR 26295, dated May 11, 1983. (ADAMS Accession No. ML033630755).

NRC, “Update of the Part 61 Impacts Analysis Methodology," NUREG-CR/4370, 1986. (ADAMS Accession Nos. ML100251399, ML100250917).

NRC, Waste Form Technical Position, Revision 1. 1991. (ADAMS Accession No. ML033630746).

NRC, “Denial of Petition for Rulemaking Submitted by the New England Coalition on Nuclear Pollution” (Docket No. PRM-61-2). March 29, 1994. ADAMS Accession No. ML093490607).

NRC, “Branch Technical Position on Concentration Averaging and Encapsulation,” *Federal Register,* (60 FR 4451, January 17, 1995). (ADAMS Accession No. ML033630732).

NRC, "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects," NUREG-1608. July 1998.

NRC, Letter from Thomas Essig, NRC, to Charles Jensen, Diversified Technologies Services. 1999. (ADAMS Accession No. ML003672318).

NRC, “Consolidated NMSS Decommissioning Guidance: Characterization, Survey and Determination of Radiological Criteria,” (NUREG-1757, Vol. 2). 2006.

NRC, “NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations” NUREG-1854. 2007 (ADAMS Accession No. ML072360184).

NRC, “Summary of Existing Guidance That May Be Relevant for Reviewing Performance Assessments Supporting Disposal of Unique Waste Streams.” 2010. (ADAMS Accession No.ML100250501).

NRC, Staff Requirements Memorandum — SECY-10-0043,”Blending of Low-Level Radioactive Waste.” October 13, 2010. (ADAMS Accession No. ML102861764)

Price, Alan, Dominion Electric Connecticut, May 15, 2002, letter to Document Control Desk, U.S. Nuclear Regulatory Commission. (ADAMS Accession No. ML021500428).

Washington Department of Health, “Technical Evaluation Report for the Portland Gas and Electric Co.’s disposal of Trojan nuclear plant reactor vessel.” (ADAMS Accession No. ML112170287).

Appendix A: Glossary

Blending	As used in this BTP, blending is the mixing of LLRW with different concentrations of radionuclides, typically in an effort to create a relatively homogeneous mixture for disposal in a licensed facility. The term blending typically is applied to mixable waste rather than mixtures of discrete items.
Classification-controlling nuclide(s)	One or more nuclides, listed in Table 1 or Table 2 of 10 CFR § 61.55, whose concentration is the specific basis for the classification of the waste container. This could be a single nuclide, or multiple nuclides that make up > 50% of the sum of fractions.
Contaminated materials	Components or metals on which radioactivity resides near the surface in a fixed or removable condition.
Encapsulation	The process of surrounding a radioactive sealed source, a collection of such sources, or other materials in a binding matrix, within a container, where the activity remains within the dimensions of the original source(s) or other materials.
Homogeneous Waste	Waste in which the concentrations of radionuclides of concern are likely to approach uniformity in the context of reasonably foreseeable intruder scenarios.
Hot spot	A volume of waste with elevated concentrations of radionuclides within a container of waste or radioactive component that may pose an unacceptable hazard to an inadvertent intruder.
Mixable Waste	Waste that is amenable to physical mixing to create relatively uniform radionuclide concentrations. In this BTP, the term is used primarily to differentiate waste that is amenable to mixing from waste that is composed of discrete items (e.g., a group of pieces of activated metal is not considered mixable waste).
Nuclide(s) of Concern	A nuclide(s) in the waste in concentrations greater than: 1% of the concentration of that nuclide listed in Table 1 of 10 CFR Part 61, or 1% of the applicable class-dependent concentration of that nuclide in Table 2 of 10 CFR Part 61, Column 2 or 3.
Nuclides other than Primary Gamma-Emitting Nuclides	All 10 CFR § 61.55 tabulated radionuclides other than Co-60, Nb-94, or Cs-137/Ba-137m.

Primary Gamma-Emitting Nuclides Cobalt-60 (Co-60), Niobium-94 (Nb-94), and Cesium-137/Barium-137m (Cs-137/Ba-137m).

Solidification The process of incorporating radioactive material a binding matrix, in a manner to create a solid, radiological homogeneous material.

Waste Types Wastes that are grouped together of the purposes of this concentration averaging and waste classification BTP. Waste types include, but are not limited to: a variety of homogeneous waste types (e.g., spent ion exchange resins blended as part of the design of a nuclear power plant, solidified liquid, absorbed liquid, evaporator bottom concentrates, ash, and filter media); activated metals; contaminated materials; cartridge filters, and sealed radioactive sources. Activated materials include neutron-activated materials or metals, or components incorporating radioactivity in their design.

Appendix B: Technical Basis for Concentration Averaging and Encapsulation Guidance

B.1 Introduction

This Appendix provides the technical basis to support the BTP's guidance for the disposal of individual items, mixtures of individual items, and mixable waste. The NRC developed this technical basis to ensure that the disposal of these wastes does not result in a dose to an inadvertent intruder that exceeds 5 mSv/yr (500 mrem/yr) as defined in the environmental impact statement (EIS) supporting 10 CFR Part 61. This BTP provides separate guidance for: (1) primary gamma emitters [Co-60, Nb-94, and Cs-137/Ba-137m], and (2) radionuclides other than primary gamma emitters. This subdivision is necessary because "hot spots" of gamma activity may be more significant to potential intruder doses than hot spots associated with the other nuclides.

B.2 Background

The concentration values shown in Tables 1 and 2 of § 61.55 for Class A, B and C low-level radioactive wastes (LLRW) are based on potential doses to an inadvertent intruder. The Part 61 environmental impact statement (EIS) uses three exposure scenarios to assess these potential intruder doses. For all three of the exposure scenarios, the NRC assumed that the intruder resides on a closed LLRW disposal site and inadvertently exhumes LLRW. In one EIS scenario the waste containers and barriers remain intact and the intruder soon recognizes the hazard and receives only a "discovery" dose. The results of this intruder-discovery scenario provide the basis for the Class B limits shown in Table 2.

In the other two EIS scenarios (intruder-construction and intruder-agriculture), the NRC assumed that the exhumed waste is indistinguishable from soil and as a result, the intruder is unaware of their interaction with the LLRW. Many LLRWs are soil-like even at the time of burial. As described in Section 4.2.1, based on experience, the NRC staff considers some of these wastes to be homogeneous without any specific demonstration of homogeneity. Homogeneous waste types include solidified or absorbed liquid, spent ion-exchange resins mixed as part of the design of a nuclear power plant, filter media, evaporator bottom concentrates, and ash. Other homogeneous wastes types, such as contaminated soil and DAW, also are considered homogeneous under certain circumstances (see Section 4.2.1). The intruder-construction and intruder-agriculture dose scenarios are the basis for the Class A and C limits shown in Table 1 and 2 of § 61.55. In the Draft and Final EISs, the NRC increased the Class A limit for Cs-137 by a factor of 20 based on the expectation that average concentrations of Cs-137 would be far below the peak allowable concentrations. In addition, in the Final EIS, the NRC increased the Class C limits by a factor of 10 over the initial values because of (1) the reduced likelihood of significant exposures due to passive warning device (markers, for example, which contain an inscription describing the nature of the hazard, can be emplaced at the disposal facility), (2) the difficulty of contacting wastes disposed of at greater depths and (3) the expectation that average concentrations will be lower than peak allowable concentrations.

After the finalization of Part 61 with its Table 1 and Table 2 Class A, B and C limits, a number of well-publicized accidents occurred that involved small, highly radioactive sealed sources. The sealed sources were typically quite small (less than 280 cubic centimeters (cc) (one-hundredth of a cubic foot (0.01 ft^3)) and some were composed of corrosion-resistant stainless steel. These accidents raised the concern at the NRC that highly radioactive items might survive for long time periods in a disposal facility and not be recognized as a hazard by an intruder. This scenario, in which a highly radioactive discrete item would survive 500 years and not be recognized by an inadvertent intruder was first considered in the 1995 version on the BTP; it was not considered by the NRC in the Part 61 EIS.

The worst of these accidents occurred in Brazil and resulted in large social disruptions, a very expensive cleanup, and radiation doses leading to deaths (IAEA, 1988). This accident in Brazil as well as accidents in the Republic of Georgia, Morocco and other locations demonstrated that the radiation hazard associated with small items is not always recognizable. Although these sources were not secured and were in locations such as abandoned buildings that were readily accessible to members of the public, the NRC decided that it would be prudent to consider the consequences of exposure to small items of LLRW. Unlike the actual events, these items in a disposal facility will be less likely to be contacted by an intruder. The disposal facility will have passive institutional controls in place, and NRC expects licensees to dispose of LLRW beneath the surface of the earth, in some cases in canisters. Some of the disposal sites are in remote locations, as well.

Therefore, a major purpose of the revised BTP is to provide guidance for the disposal of discrete individual highly-radioactive items or mixtures of items that fall within the "envelope of safety" defined in the EIS for Part 61. This guidance is based on two gamma source handling scenarios: (1) the gamma sealed source carry-away scenario and (2) the gamma source large items carry-away scenario. Further, the BTP also provides guidance on classification for mixable waste.

B.3 Overview of Gamma-Emitting Sealed Source Carry-Away Scenario (Basis for the Encapsulation Position for Gamma Emitters)

Scenario

Five hundred years after closure of a LLRW landfill, the LLRW containers have decayed and the mixable wastes and encapsulating materials have become soil-like. However, a stainless steel Cs-137 sealed radioactive source has survived as an individual, recognizable item.

As a result of a public works project, such as the construction of a regional pipeline, a trench is cut through the former LLRW landfill. The construction crew notices soil conditions are different, but the crew has been contracted to cut kilometers (miles) of trench and they continue their excavations. An individual finds the sealed radioactive source in the excavated soil. The small piece of metal looks very old. There is no indication of a hazard. The individual takes this interesting piece of metal home, where it is placed with other curios on a shelf in the living room. For the first 4 hours, the sealed source is in the individuals coat pocket (3 cm exposure distance) and after that, on average, the individual is 2 meters from the sealed source, reading or performing some other activity for 15 hours per week, 48 weeks out of the year.

NRC Analysis:

Using MicroShield®, the NRC determined that a 4.8 TBq (130 Ci) Cs-137 source (at the time of disposal) would result in a 5 mSv (500 mrem) dose to the intruder at 500 years. Thus Cs-137 sources should be limited to 4.8 TBq (130 Ci) at the time of disposal as Class C LLRW to ensure that intruder doses do not exceed 5 mSv (500 mrem). If this same scenario is applied 100 years after site closure (Class A) the limit is 266 MBq (7.2 mCi) at the time of disposal, and the limit is 27 GBq (0.72 Ci) at 300 years for Class B disposal.

Using the above scenario with a Co-60 sealed source, the NRC determined the calculated activity is 1.1 TBq (30 Ci) for Class A (100 years) at the time of disposal, with no activity limit for a Co-60 source that can be disposed as Class B (300 years) or Class C (500 years). For Table A, "Activity Levels of Primary Gamma Emitters in Individual Items Potentially Requiring Piecemeal Consideration in Classification Determinations" (Section 4.3.2), and for the encapsulation guidance (Section 4.5), the staff has increased the Class A value for Co-60 from 1.1 TBq to 5.2 TBq (30 Ci to 140 Ci). The staff selected 5.2 TBq (140 Ci) because it is the amount of Co-60 that could be disposed in a 0.2 m^3 (~55 gallon) drum at the Class A limit. The dose from a 5.2 TBq (140 Ci) Co-60 source will be 5 mSv/yr (500 mrem/yr) at 111 years. Therefore, the new value of 5.2 TBq (140 Ci) continues to protect the intruder because of Co-60's short half life.

If this same scenario is applied to a point source of Nb-94, the activity constraint at the time of disposal, at 100 years, at 300 years, and at 500 years would be less than 37 MBq (1 mCi); however the slightly higher limit of 37 MBq (1 mCi) was selected for practical considerations.

Additional Modeling Details:

- Disposal of a Cs-137 sealed source (500 years) -- The NRC assumed that the source is an elongated cylinder of CsCl (density = 2.7 g/cc (169 lbs/ft^3)) which is 2.7 cm (1.06 in) tall and 1.5 cm (0.59 in) in diameter lined with 0.47 cm (0.19 in) of stainless steel.

- Disposal of Cs-137 sealed sources (100 years and 300 years) -- The NRC assumed that the source is an elongated cylinder of CsCl which is 1 cm (0.39 in) tall and 0.56 cm (0.22 in) in diameter lined with 1 cm of stainless steel.

- Disposal of Co-60 sealed sources (100 years) -- The NRC assumed that the source is a square cylinder of Co-60 1 cm (0.39 in) tall and 1 cm (0.39 in) in diameter.

B.4 Disposal of Primary Gamma Emitters in Activated Metals or Contaminated Materials or Cartridge Filters (Basis for Table A and the Factor of Two Rule)

The guidance for the disposal of primary gamma emitters evolved from the NRC's work on sealed sources. If the gamma-emitting activity of sealed sources were contained in individual pieces of activated metals, or cartridge filters or contaminated materials, the hypothetical intruder would not sustain a dose greater than that calculated for sealed sources because of the typical distribution of the activity over a larger volume and in materials that may exhibit a degree of self-shielding.

The NRC used this analysis to create Table A, “Activity Levels of Primary Gamma Emitters in Individual Items Potentially Requiring Their Piecemeal Consideration in Classification Determinations,” in Section 4.3.2. Sealed source-like items that are smaller than 280 cc (0.01 ft^3) and that exceed the Table A values, should be managed individually for the purpose of waste classification. The NRC derived the Table A values at 100 years after disposal for Class A waste, at 300 years after disposal for Class B waste, and at 500 years after disposal for Class C waste using the gamma source carry-away scenario described above.

Finally, since sealed sources, activated materials and metal, and components containing radioactivity in their design may be disposed of in the same disposal container with other waste of similar type containing the same gamma-emitting nuclide, acceptable concentration averaging guidance is included for these situations. The Table A guidance is introduced to ensure that gamma-emitting sealed source-like materials are removed from mixtures and managed separately. The remaining contents can always be classified based on the highest classification of any specific item in the container. Averaging is also acceptable if the concentration of each primary gamma-emitting nuclide in each individual item in the disposal container does not exceed two times the classification limit for that nuclide for the classification of the mixture (Class A or B or C). This Factor of Two Rule precludes hot spots in gamma-emitting waste from significantly affecting projected intruder doses irrespective of whether the intruder is exposed through the intruder-agricultural scenario or through direct interactions with the waste (e.g., handling scenarios). The NRC used the following handling scenario to set the Factor of Two Rule that limits gamma-emitting hot spots in a container holding individual items.

Gamma-Emitting Larger Items Carry-Away Scenario:

<u>Scenario</u>

Five hundred years after closure of a LLRW landfill, a 2.55 m^3 (90 ft^3) LLRW container (a B-25 box) in the landfill has decayed leaving the individual pieces of activated stainless steel. It is assumed that there are 1.7 m^3 (60 ft^3) of activated stainless steel pieces in the container. One half of the pieces 0.85 m^3 (30 ft^3) contain Nb-94 at two times the Class C limit and one half of the pieces contain Nb-94 at well below the Class C limit.

As a result of a public works project such as the construction of a regional pipeline, a trench is cut through the landfill. The construction crew notices the large pieces of steel in the excavated soil. There is no indication of a hazard and the crew uses their construction equipment to move the pieces of steel to their shop for storage and resale to a scrap metal dealer 6 months later. For computational ease it is assumed that only the higher activity pieces are removed and that each piece of steel is a 0.03 m^3 (1 ft^3) square. Each piece of metal is moved three times and the cumulative exposure time for each piece is 21 minutes (7 minutes per move) at 15 cm (6 inches). In the crew’s shop the individual is exposed for 5 hours per week for 6 months at a distance of 2 m (6.6 ft) from the 0.85 m^3 (30 ft^3) stack of blocks.

<u>NRC Analysis:</u>

Using MicroShield® and the above parameters, the projected dose to the intruder is 5 mSv (505 mrem). Thus, individual pieces of activated metal should not exceed two times the Class C limit to ensure intruder doses do not exceed 5 mSv (500 mrem). This rule is applicable to a mixture that is classified as Class C, but would not be protective if applied to a Class A or B mixture. Therefore this rule is linked to the classification of the resulting mixture. Simply stated, the concentration of a primary gamma-emitting nuclide in any item of the mixture should not exceed two times the classification limit for that nuclide, for the classification of the mixture (Class A or B or C). This Factor of 2 Rule removes gamma-emitting hot spots from mixtures of items and the Factor of 2 Rule also places an absolute limit on the boundary between Class C and GTCC for individual items in a mixture, where the primary gamma emitters control the classification.

B.5 Disposal of Alpha- and Beta-Emitting Sealed Sources (Basis for the Encapsulation Position for Non-gamma Emitters)

If an alpha- or beta-emitting sealed source is inadvertently excavated, the only exposure pathways are ingestion or inhalation (breathing re-suspended material or ingesting material from contaminated foodstuffs). Neither of these pathways depends on localized hot spots as long as the average concentration over a large area is unaffected. Therefore, the NRC believes that the curie limits for alpha- and beta-emitting sealed sources are constrained by the source activities averaged over the weight or volume of the encapsulated source (typically a 0.2 m^3 (~55 gallon) drum). For alpha or beta sources, this limit is 0.2 times the 10 CFR § 61.55 class limit for that nuclide. For example, a Sr-90 source should not exceed 52.5 TBq (1400 Ci) (261TBq/m^3 (7000 Ci/m^3, the Class C limit for Sr-90) x 0.2 m^3). The largest activity of a transuranic nuclide, other than Pu-241 and Cm-242, that is generally acceptable for encapsulation in 0.2 m^3 (~ 55 gallon) is about 1.1 GBq (30 mCi), presuming the density of the encapsulating mass is 1.3 g/cm^3 (81.3 lbs/ft^3). When calculating mass-based concentrations, it is generally acceptable to take credit for the actual density of the material if the density is less than 2.2 g/cm^3 (137.5 lbs/ft^3).

B.6 Disposal of Nuclides other than Primary Gamma Emitters in Activated Metals, or Contaminated Materials or Cartridge Filters (Basis for Table B and the Factor of 10 Rule)

In this case, the BTP defines a “mixing” constraint that is within the context of the general waste classification rationale expressed in the documentation that supports the Part 61 regulation. In defining this constraint, it was noted that the § 61.55 concentration values that delineate the boundaries between different waste classes (i.e., A, B, and C) typically differ by more than one order of magnitude. To limit the mixing of items from different waste classes, this BTP allows concentration averaging of the alpha and beta emitting activity in individual items if the specific activity of each *nuclide(s) of concern* in each item is within a factor of 10 of the classification limit for that nuclide for the classification of the mixture.

This Factor of 10 Rule also places an absolute limit on the boundary between Class C and Greater-Than-Class C (GTCC) for individual items in a mixture, where the non-primary gamma emitters control the classification.

The rationale used to construct Table B is consistent with the encapsulation position in the BTP for non-primary gamma emitters and the position is the same as the rationale used to construct Table A (i.e., if an item is too hot to be encapsulated, it is too hot to be averaged in a mixture). Since any potential intruder dose is essentially independent of alpha and beta (or non-primary gamma-emitter) hot spots, the numerical values in Table B reflect the maximum activity that would be allowed if the activity was contained in a sealed source encapsulated in a 0.2 m^3 (~55 gallon) drum, and a minimum volume criterion is not necessary.

B.7 Intrusion into Mixable Waste (Basis for the Threshold for Demonstrating Homogeneity and the Homogeneity Test)

As discussed above, the NRC based the waste classification limits in 10 CFR § 61.55 on hypothetical scenarios in which an individual inadvertently constructs a dwelling on a waste site and another individual subsequently lives in that dwelling, exposing each to LLRW. Individuals constructing a dwelling and disrupting multiple waste packages would likely be exposed to waste at or below the class limit because waste in multiple containers that each meet the class limit cannot, in aggregate, exceed the class limit. Individuals exhuming a small amount of waste, however, are more susceptible to encountering hot spots in the waste because they may exhume waste from only one part of a waste package. Thus, an intruder exhuming only a small amount of waste is the limiting scenario that needs to be considered with respect to waste homogeneity. Typically, individuals exhuming only a small amount of waste are protected by the small inventory they encounter. However, in some cases, an intruder exhuming a small amount of waste could receive a dose comparable to an intruder exhuming multiple packages (if the small volume of waste is significantly more concentrated than the package average).

<u>Scenarios</u>

The NRC staff expects that the range of reasonably foreseeable intrusion scenarios at a particular disposal site will depend on site-specific conditions. However, the staff believes that well drilling is a reasonably foreseeable activity under a variety of site and disposal conditions. In developing the mixable waste guidance in this document, the NRC staff considered doses to an individual unknowingly drilling a well into a waste site (acute scenario) and another individual subsequently living and gardening on the site (chronic scenario). The staff considered two different types of well-drilling scenarios. In the first, a mixture of drill cuttings and drilling mud is placed in a disposal pit near the well and covered with clean soil (mud rotary drilling scenario). In the second, a similar well is drilled but drill cuttings are spread on the land surface and mixed into the top 15 cm (6 in.) of soil (exposed drill cuttings scenario). In both scenarios, intrusion occurs at either 100 years after site closure (for Class A waste) or 500 years after closure (for Class C waste). Subsequently, in both scenarios, another individual lives on the land and creates a garden near the well.

Drilling methods in which cuttings are spread on the land surface (e.g., cable tool drilling, auger drilling), though not as common as mud rotary drilling, are sometimes used for water well drilling. These drilling methods also have other applications, such as drilling boreholes for site exploration. In addition, a scenario in which an intruder drills a well and spreads drill cuttings on the site serves as a surrogate for other potential intrusion scenarios in which a small amount of waste is exposed on the land surface. Drilling scenarios in which cuttings are spread on the land surface are commonly used in both NRC and DOE LLRW analyses (NRCP, 2005; Koffman et al., 2005).

<u>NRC Analysis</u>

The intruder in the acute drilling scenario is exposed through direct exposure, dust inhalation, and incidental soil ingestion. The chronic intruder is exposed through these pathways as well as consumption of ground water and plants grown on site. In general, the NRC found that doses to the chronic intruder were more limiting than acute doses to the individual drilling the well.

For the mud rotary drilling scenario, the NRC staff used RESRAD (Version 6.5) to estimate the dose to an individual inhabiting the site after drilling is complete. The staff assumed that an intruder exhumes a unit volume (0.03 m^3 [1 ft^3]) of waste with a sum of fractions of 10 for a series of hypothetical wastes, each dominated by one of the 10 CFR § 61.55 listed nuclides. The waste is assumed to be diluted with soil from below and above the waste disposal site and placed in a disposal pit under 1 m (3.3 ft) of clean cover. The NRC staff assumed water is drawn from a well at the edge of the drilling mud disposal pit and used for drinking water and crop irrigation. In the mud rotary drilling scenario, because the cuttings are initially covered, the hazard from short-lived gamma emitters (e.g., Cs-137), which is important to dose in the exposed drill cutting scenario, is essentially eliminated. Instead, the primary exposure pathways are from radionuclides leaching into groundwater and exposure to long-lived gamma emitters after sufficient erosion has taken place at the site to expose the cuttings in the disposal pit.

Because the dose in the mud rotary drilling case is primarily due to long-lived radionuclides (i.e., C-14, Tc-99, and Nb-94), there is very little difference in source term between intrusion at 100 and 500 years. Because the Class C limits for these long-lived radionuclides are a factor of 10 greater than their Class A limits, the predicted dose from intrusion into Class C waste at 500 years is essentially a factor of 10 greater than the dose from intrusion into Class A waste at 100 years. Furthermore, postulating longer-lived intrusion barriers has little effect on the predicted dose. That is, assuming that intrusion does not occur until 800 or 900 years has little effect on the potential dose from these long-lived radionuclides. Thus, while no safety concerns were identified for intrusion into Class A waste in the mud rotary drilling scenario, the staff found that a 0.1 m^3 (3.5 ft^3) hot spot with a sum of fractions of 10 or greater in Class C waste could present more of a concern. However, the potential hazard in the mud rotary drilling scenario is primarily due to radionuclides that are not expected to be present in significant concentrations in commercial LLRW (i.e., Tc-99, C-14, Nb-94). The improbability of any of these radionuclides contributing significantly to the hazard from commercial LLRW suggests it would not be consistent with ALARA principles for waste generators or processors to routinely conduct measurements to evaluate the homogeneity of waste based on a postulated mud rotary drilling intrusion scenario.

For the exposed drill cutting scenario, the NRC used a model developed in the simulation software package GoldSim® (Version 10.5) to conduct its analyses. The NRC staff also developed a RESRAD model to represent the scenario and obtained similar results. The GoldSim analyses treated the garden area, well diameter, cuttings distribution area, well depth, occupancy factors, and several environmental parameters (e.g., soil sorption coefficients, plant uptake factors) probabilistically. The model assumed that waste was mixed poorly and contained pockets of waste with significantly greater than average concentrations. The model also assumed that waste filled a container unevenly (i.e., not in complete horizontal layers) such that, in one location of the container, more than 10% of the depth of waste could exceed 10 times the concentration limit while the entire container still meets the classification limit. The NRC calculated the volume of waste that could be exhumed at 10 times the classification limit while maintaining an intruder dose below 5 mSv/yr (500 mrem/yr) for a series of hypothetical wastes, each dominated by one of the 10 CFR § 61.55 listed nuclides.

The staff obtained similar results for waste at the Class A limits evaluated at 100 years or waste at the Class C limits evaluated at 500 years. In both cases, the staff found that exhuming approximately 0.03 m^3 (1 ft^3) of waste with a sum of fractions of 10 led to a dose of approximately 0.25 mSv/yr (250 mrem/yr). The most limiting radionuclide at the Class A limit is Cs-137, with a dose primarily due to external exposure. For waste at the Class C limit, the largest doses are caused by Nb-94, Np-237, several other transuranic elements, and Cs-137. Because waste disposed as activated metal is not consistent with the underlying assumptions of the chronic drilling scenario (i.e., it is not expected to be soil-like at 500 years), the NRC did not base the limiting volume on the Nb-94 dose. Similarly, because very little Np-237 is disposed in commercial LLRW, the NRC did not use the Np-237 dose to determine the limiting volume. The Nb-94 and Np-237 doses are approximately a factor of six and four, respectively, greater than the next highest doses. Thus, in the very unlikely case that a chronic intruder in a well-drilling scenario encounters 0.03 m^3 (1 ft^3) of waste from a hot spot dominated by either Nb-94 or Np-237 at 10 times the class limit, the dose would be within a factor of three or two of the 5 mSv/yr (500 mrem/yr) limit if most of the dose is from the hot spot (i.e., if the exhumed waste from outside the hot spot contributes little to dose).

In hypothetical waste streams each assumed to be dominated by a single radionuclide at the Class C limit, the predicted dose from a hot spot of Cs-137 is similar to predicted doses from hot spots of several transuranic elements (i.e., exhuming 0.03 m^3 (1 ft^3) with a sum of fractions of 10 led to a dose of approximately 2.5 mSv/yr (250 mrem/yr)). These doses are attributable to direct exposure (Cs-137), plant ingestion (transuranic elements and, to a lesser extent, Cs-137), and dust inhalation (transuranic elements).

Geometric Assumptions

In this analysis, the staff subjectively chose to represent a hot spot as a sphere. Although more conservative assumptions could be made (e.g., a vertically-oriented cylindrical hot spot that coincides with the intruder's drill bore) the NRC staff judged these geometries to be too improbable to form the basis for the guidance (i.e., not reasonably foreseeable). The staff also subjectively assumed an intruder would use a 0.2 m (8 in.) well bore. Other assumptions could be used and would yield slightly different results. The staff used these assumptions to calculate the amount of activity an intruder would exhume from hot spots of various sizes with various sums of fractions. For example, based on these assumptions, an intruder encountering a 0.15 m^3 (5 ft^3) hot spot with a 0.2 m (8 in.) diameter well bore would exhume approximately 0.02 m^3 (0.7 ft^3) of waste (Figure B-1). In calculating the volume of waste from a hot spot that would be intersected by a 0.2 m (8 in.) well bore, the staff neglected the curvature of the section of the sphere intersected by the well bore and assumed that the length of the well bore intersecting the hot spot is equal to the diameter of the sphere. The staff considers this approximation to be appropriate because the effect of the approximation on the calculated volume is much smaller than effect of assuming the hot spot to be roughly spherical.

These geometric assumption define the relationship between the volume of a hot spot, the sum of fractions of the hot spot (if the sum of fractions is constrained only by the total activity in the package at the class limit), and the volume of waste exhumed by an intruder using a 0.2 m (8 in.) well bore.

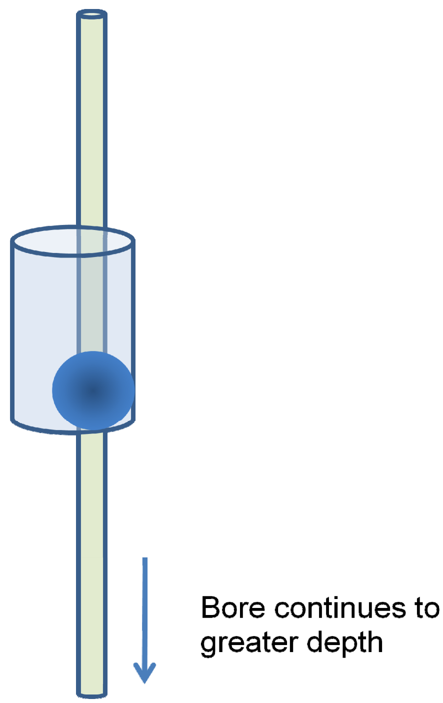

Figure B-1. Simplified diagram of well bore intersecting hot spot in container of mixable waste. Diagram shows approximation of 0.2 m (8 in.) well bore intersecting 0.15 m^3 (5 ft^3) hot spot in a 5 m^3 (180 ft^3) (internal volume) package.

Development of a Threshold for Demonstrating Homogeneity

To determine when waste homogeneity should be demonstrated, the NRC staff considered the potential consequence of allowing hot spots in mixable waste to be constrained only by the total activity in a package at the classification limit. That is, the staff considered the activity that could be contained in hot spots of various sizes if essentially all of the activity in the package were concentrated in the hot spot. For example, a 5 m^3 (180 ft^3) package could contain 1.9×10^{11} Bq (5 Ci) of Cs-137 at the Class A limit. If the total activity in this example package were concentrated in a 0.15 m^3 (5 ft^3) hot spot, the specific activity of the hot spot would be 1.2×10^{12} Bq/m^3 (33 Ci/m^3) and the sum of fractions of the hot spot would be 33. Because a larger package can contain more activity for a given waste class, the consequences of concentrating the activity in a hot spot is greater for larger packages.

For a fixed package size (i.e., for a fixed amount of activity), each hot spot size corresponds to a different maximum sums of fractions. Based on the geometric considerations discussed previously, each hot spot size also corresponds to an amount of waste an intruder could exhume from the hot spot with a 0.2 m (8 in.) well bore. Based on the volume of waste exhumed from the hot spot and the maximum potential sum of fractions of the hot spot, the NRC staff calculated the amount of activity exhumed. The staff then used the projected dose from the exposed drill cutting scenario to relate the activity exhumed for each hypothetical hot spot volume to a potential dose (Figure B-2). In general, if the well bore diameter is fixed, an intruder could exhume a greater fraction of a small hot spot than a large hot spot. Therefore, the dose to an intruder encountering a hot spot increases with decreasing hot spot size until the hot spot becomes so small that the well bore exhumes the entire hot spot, at which point further decreases in hot spot size do not affect the amount of activity exhumed.

To determine when waste homogeneity should be demonstrated, the staff used these approximate doses to establish hot spot volumes and concentrations that could lead to an unacceptable dose if intrusion occurred (i.e., consequences greater than 20 mSv/yr [2 rem/yr]). The NRC staff also considered hot spot volumes and sums of fractions that would lead to doses that could be managed by reducing the probability of occurrence (i.e., consequences less than 20 mSv/yr [2 rem/yr]). As described in Section 4.2.2, the staff used these ranges of hot spot sums of fractions to establish concentration differences and volumes of waste that would meet the threshold for demonstrating homogeneity.

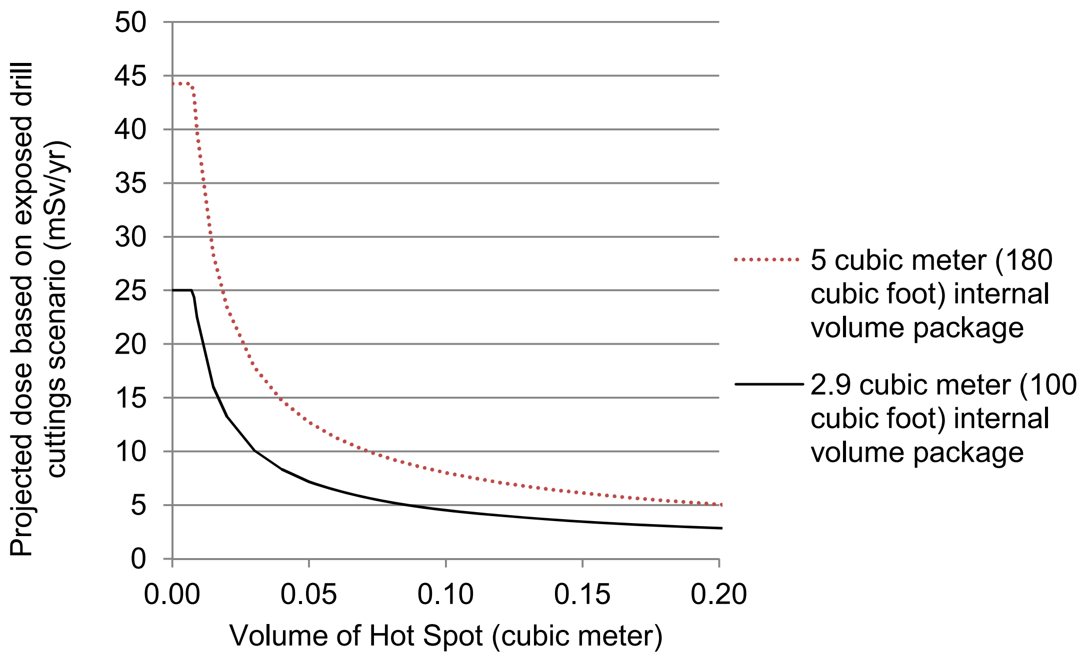

Figure B-2. Estimated dose to an intruder exhuming waste from various size hot spots in 5 m^3 (180 ft^3) or 2.9 m^3 (100 ft^3) packages if the sum of fractions in the hot spot is constrained only by the waste class of the package. The dose is based on chronic exposure to drill cuttings spread on the land surface.

Development of a homogeneity test

For an assumed well-drilling scenario, including an assumed well bore diameter, the dose to an inadvertent intruder who encounters a hot spot depends on the volume of the hot spot exhumed and the sum of fractions of the hot spot. As previously discussed, to determine when homogeneity should be demonstrated, the staff considered potential doses if no homogeneity test is applied. To develop a homogeneity test, the NRC staff considered how the amount of activity in a hot spot would be constrained by various tests. To make these comparisons, the staff considered various sizes and activities of hot spots that could comply with each test. For example, if a test ensured that no hot spot of 0.1 m^3 (3.5 ft^3) or larger had a sum of fractions greater than 10, the waste could contain a hot spot of 0.01 m^3 (0.35 ft^3) with a sum of fractions of 100 or a hot spot of 0.05 m^3 (1.8 ft^3) with a sum of fractions of 20. A larger hot spot with an activity at the test limit (e.g., 0.2 m^3 [7 ft^3] with a sum of fractions of 10) also would meet the test criterion. The staff used this type of calculation to determine the maximum sum of fractions in hot spots of various sizes based on different potential tests (i.e., different test volumes with different maximum sums of fractions).

The staff then estimated how much activity could be exhumed from hot spots as a function of size if the sum of fractions was constrained by various potential homogeneity tests. As in the development of a threshold for demonstrating homogeneity, the staff used the approximation that exhuming the activity equivalent to exhuming 0.03 m^3 (1 ft^3) with a sum of fractions of 10 resulted in a dose of approximately 2.5 mSv/yr (250 mrem/yr) to associate approximate doses with each test (Figure B-3). The staff used this information to choose a test that would limit potential doses from the exposed drill cutting scenario to a range in which the IAEA recommends doses can be managed by limiting the probability of occurrence (i.e., less than 20 mSv/yr [2 rem/yr]). A test based on a 0.15 m^3 (5 ft^3) volume with a sum of fractions of 10 limits potential doses to approximately 13 mSv/yr (1.3 rem/yr). This dose allows additional margin for the dose from the remainder waste in the well bore (i.e., from packages above and below the package with the hot spot).

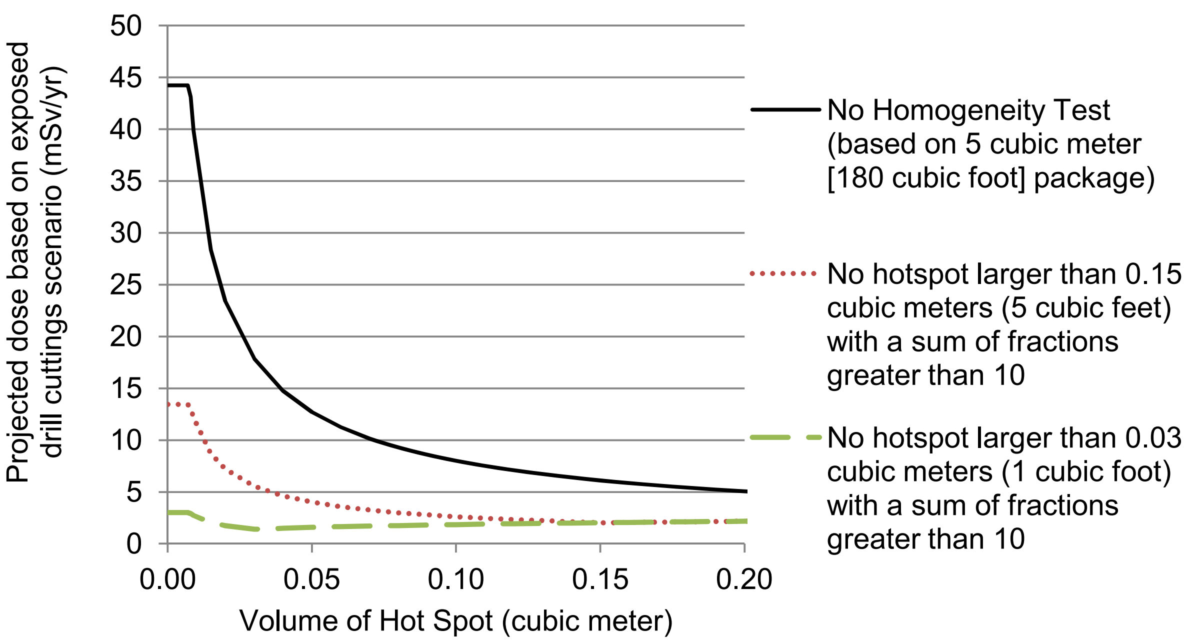

Figure B-3. Potential doses from hot spots limited by two potential homogeneity tests or by total package activity (i.e., no homogeneity test) based on an exposed drill cuttings scenario. Calculations are based on a 0.2 m (8 in.) well bore and 5 m^3 (180 ft^3) waste package.

References:

Koffman, L;Patricia Lee, P;Jim Cook, J; et.al. “Automated Inadvertent Intruder Application,” Savannah River National Laboratory, May 29, 2007, report number WSRC-STI-2007-00295

NCRP 2005, NCRP Report No. 152, "Performance Assessment of Near-Surface Facilities for Disposal of Low-Level Radioactive Waste Recommendations of the National Council on Radiation Protection and Measurements," December 31, 2005.

Appendix C: NRC Staff Responses to January 26, 2011, Federal Register Notice and February 24, 2011, Public Workshop Comments

Background:

In developing the August 2011 revision to the January 17, 1995, Branch Technical Position on Concentration Averaging and Encapsulation, the NRC solicited public input on potential revisions to the document. On January 26, 2011, the staff published a Federal Register notice (76 FR 4739) containing questions related to potential revisions. These questions and other issues related to revising the BTP were discussed by stakeholders with the staff at a February 24, 2011, workshop held in Rockville, MD. In addition, members of the public could respond to the questions and other issues related to potential BTP revisions in writing. The comment period closed on April 15, 2011.

Comments received from the public related to revisions to the BTP are addressed below and were considered by the staff in developing the August 2011 draft revision. This appendix contains a summary of how the public's issues and concerns were addressed by the staff in that draft revision. Where staff responses below have been superseded by the May 2012 draft of the BTP, a note to that effect has been added.

Stakeholder Input:

The following are the documents related to stakeholder input on potential revisions to the BTP.

Document Type	Author	Date	Organization	ADAMS ML #
Federal Register Notice, Vol. 76, No. 17, page 4739. Includes Sandia draft of BTP mentioned in public comments below.	NRC staff	January 26, 2011	NRC	N/A
Meeting Summary, February 24, 2011, Workshop	Maurice Heath	March 30, 2011	NRC	ML110880417
Meeting Transcript, February 24, 2011, Public Workshop on the BTP	N/A	February 24, 2011	NRC	ML110600395

Document Type	Author	Date	Organization	ADAMS ML #
Letter	John LePere	April 15, 2011	WMG Inc.	ML11111A132
Letter	J. Scott Kirk	April 15, 2011	Waste Control Specialists, Inc.	ML11111A133
Letter	Thomas Magette	April 15, 2011	EnergySolutions	ML11119A021
Letter	Abigail Cuthbertson	April 18, 2011	Department of Energy, National Nuclear Security Administration	ML11119A022
Letter	Leonard R. Smith	April 15, 2011	Council on Radionuclides and Radiopharma-ceuticals	ML12083A080
Letter	Edward F. Maher	April 22, 2011	Health Physics Society	ML11116A125
Letter	Lisa Edwards	May 13, 2011	Electric Power Research Institute	ML11138A230
1995 Concentration Averaging BTP	NRC	January 17, 1995	NRC	ML033630732
2011 Draft Revision to Concentration Averaging BTP	Sandia Labs	January 28, 2010	Sandia Labs	ML103430088

Analysis of Comments:

The staff analyzes the public comments received in the sections below. The comments are grouped by issues. Each issue is described, analyzed, and a staff conclusion or resolution of the issue is presented.

1. Homogeneous Wastes, Including Blending:

a. Removal of Current Constraints on Homogeneous Wastes

One commenter asked that the constraints on averaging of homogeneous materials be eliminated. In a related comment, another stakeholder requested that the NRC remove the factor of 10 applied to batches before mixing.

Staff Response:

In SECY-10-0043, the NRC proposed to remove the constraint that, before wastes may be mixed, radionuclide concentrations in those wastes should be within a factor of 10 of the average concentration in the final mixture (called the "factor of 10" rule). The NRC indicated that this rule, because it is based on the inputs to a process rather than the outputs, was not performance-based. In the Staff Requirements Memorandum (SRM-SECY-10-0043), the Commission agreed with staff's proposed option, which included eliminating the factor of 10 rule for mixtures of homogeneous wastes. The revised BTP reflects that decision and does not include constraints on the inputs to mixtures of homogeneous wastes. Instead, the BTP provides guidance on criteria that mixtures of homogeneous wastes created through large-scale blending should meet before being considered homogeneous. Waste streams that are designated as homogeneous waste types (i.e., solidified liquid, spent ion-exchange resins, filter media, evaporator bottom concentrates, contaminated ash, contaminated soil, and containerized dry active waste (DAW) may continue to be regarded as homogeneous unless available information indicates significant heterogeneities, as discussed in Section 3.2.1 of the BTP.

[Note—The guidance for testing the homogeneity of waste generated with large-scale blending has been replaced with guidance for determining the homogeneity of waste that meets certain criteria related to the volume of waste produced and the concentrations of the input waste streams (Section 4.2.2.1, Table 1). In addition, the BTP provision regarding "available information" identified in the original comment response has been removed from the May 2012 draft].

b. Sampling and Measurements

One commenter suggested that the NRC should provide specific requirements on the types of measurements and numbers of samples from blending equipment needed to demonstrate that the average concentration and measurement uncertainty are known to a limit that would be acceptable to the NRC and the Agreement States. Another argued that licensees need to understand the measurement uncertainty in relation to potential impacts to the intruder and recommended that the NRC provide specific examples on acceptable methods to address the five sources of uncertainty in the Interim Guidance (NRC's March 17, 2011 letter to the Agreement States, ADAMS ML110480850). The commenter also suggested that there should be a requirement for waste processors to collect independent verification samples from the generators' waste stream for large-scale blending.

Staff Response:

[This response has been superseded in the May 2012 draft].

As discussed in the BTP, the number of samples necessary to demonstrate waste classification requirements have been met depends on the magnitude and sources of uncertainty in the final concentration values and how close the average sum of fractions is to the class limit. Section 3.2.3 of the BTP (August 2011 draft) provides guidance on determining the appropriate number of samples to demonstrate waste classification requirements have been met and handling of associated uncertainties.

The NRC expects that the types of measurements appropriate for demonstrating the average concentration and associated uncertainty of waste intentionally blended during waste processing will depend on specific features of the blending process and input wastes. For example, some processes may be amenable to surveys conducted while waste is being recirculated, while others may not have appropriate survey locations or may not use wastes amenable to quantification through surveys and may require waste to be sampled from a holding tank or disposal container. Thus, the types of measurements used will be chosen by the licensee based on specific waste and process features. The revised BTP does recommend independent verification of waste streams that are processed by intentional blending if the demonstration of homogeneity or waste classification is based on process knowledge and the properties of the incoming waste streams. If homogeneity and waste classification are, instead, based on testing of the final waste form, incoming waste streams should be verified to whatever extent necessary for the processor to maintain good process control.

c. Radiation Doses to an Inadvertent Intruder:

One commenter noted that Enclosure 2 of the current BTP contains an analysis of the radiation doses to an intruder encountering waste at the upper end of Class C limits. The commenter encouraged NRC to include a similar analysis for waste blended to the upper end of Class A.

Staff response:

[This response has been superseded by the May 2012 draft].

As noted by the commenter, Enclosure 2 of the 1995 BTP includes a summary of an analysis of the radiation doses to an intruder encountering waste at the upper end of the Class C limit. The enclosure included this analysis because it formed the basis for the 1995 BTP guidance on the disposal of sealed sources. Appendix B of the revised BTP includes a summary of analyses of a well driller encountering a relatively small volume of waste at a concentration exceeding either Class A or Class C limits because these analyses form the technical basis for the revised BTP guidance on demonstrating waste homogeneity. Specifically, the analyses determine the volume of waste with concentrations exceeding 10 times the relevant class limits that would cause an intruder a dose of 0.5 mSv/yr (500 mrem/yr). Waste exceeding 10 times the classification limit was considered because it exceeds the range of concentrations that is recommended in the BTP for mathematical averaging. The results of the analyses were used to determine the size of a sub-volume of waste that would constitute an intruder hazard and, therefore, indicated that a waste should be more thoroughly mixed before being considered homogeneous.

d. Coordination among Agreement States

One commenter asked that the BTP address the need for coordination between Agreement States that regulate processing/blending of LLRW and those that regulate disposal facilities. Such coordination was recommended by NRC in the Interim Guidance on LLRW blending issued on March 17, 2011.[13]

Staff Response:

[Note—this response has been superseded by the May 2012 draft.]

The staff agrees. New text has been added to Section 1.0 to address coordination between Agreement States.

e. Exemptions from Blending Constraints

One commenter noted that mixing or blending of LLRW streams occurs at licensed facilities as a matter of facility design and that this practice was recognized by NRC subsequent to the 1983 position (i.e., in the 1995 BTP). The commenter recommended that the exclusion that applies to operational efficiency and worker dose reduction should continue to apply in the revised BTP.

Staff Response:

[This response has been superseded by the May 2012 draft].

The NRC understands that a certain amount of mixing of waste streams occurs at licensed facilities because of the facility design (e.g., if a single holding tank is used for multiple resin waste streams) or for reasons of operational efficiency or worker dose reduction. This type of mixing is not expected to cause the same risk to an inadvertent intruder as intentional blending during waste processing (i.e., large-scale blending). Disposal of large-scale blended waste potentially poses an increased risk because: (1) waste resulting from large-scale blending is expected to have a sum of fractions closer to the classification limit than incidentally blended waste, and (2) processors engaging in large-scale blending of waste are expected to produce more blended waste than generators who blend waste incidentally. The first factor could increase risk to an intruder by increasing the consequences of intruder interaction with the waste. The second factor could increase risk to an intruder by increasing the probability that an intruder constructing a dwelling or well (or otherwise disrupting the site) at a random location on site will interact with blended waste near the classification limit. For these reasons, use of the term large-scale blending in this BTP excludes the incidental blending described by the commenter. The specific exclusion from

[13] See ADAMS ML110480839 and ML110480850.

the factor of 10 constraint on mixing homogeneous waste types is not included in the revised BTP because the factor of 10 constraint on mixing has been eliminated.

f. Stranding of existing blended waste

Changes in blending processes and procedures caused by new regulatory guidance or requirements could strand radwaste in process or in extended storage, and may require an update to the processes and procedures for any blending activities that are approved.

Response:

The staff's focus for LLRW blending has been on "large-scale blending" that potentially could take a significant fraction of the existing Class B/C waste stream and convert it to Class A through blending with lower concentration Class A waste. Such blending [could] increase the amount of waste near the Class A limit that was disposed of and increase the potential of an inadvertent intruder receiving an unacceptable radiation exposure. The staff does not believe that existing practices for blending would be significantly impacted by the new guidance,

g. Other:

In Section 5 (homogeneous wastes) of the revised draft published for public comment on January 26, 2011, (the "Sandia draft)," the commenter recommended the removal of the last paragraph as not being applicable to this section. (The last paragraph reads, "If a waste container holds a mixture of similar waste types that are not radiologically homogeneous (node C), proceed to Section 6, "Classifying a Mixture of Items of the Same Waste Type").

Staff Response:

This paragraph has been removed.

2. Classification of Individual Wastes, Including Factors of 1.5 and 10:

   a. Commenters requested that the NRC eliminate these factors for "primary and non-primary gamma emitters" in the BTP, noting that mixing during the intruder scenario eliminates the need for these constraints. One commenter specifically requested that NRC remove the constraints on averaging irradiated hardware including eliminating the factor of 1.5 for averaging Nb-94. Another stated that, based on historical disposal data, it is evident that the factor of 1.5 for gamma driven classification of waste packages is arbitrarily limiting and does not result in any appreciable additional protection. The commenter also argued that application of the factor of 10 in all cases results in an appropriate limitation to mathematical averaging of heterogeneous wastes within a package where physical blending cannot reasonably occur.

   Staff Response:

   The NRC has conducted an additional analysis and determined that, to protect an inadvertent intruder, it is necessary to limit gamma-emitting hot spots in mixtures of contaminated materials or activated metals or cartridge filters. The proposed new position limits hot spots in a mixture to no more than 2x the appropriate Class limit for the classification-controlling primary gamma emitters. This limit applies if the classification is determined by the primary gamma-emitting isotopes. The current 1995 position limits gamma hot spots to 1.5x the average concentration of the mixture. While the 1995 position ensures uniformity in the waste concentrations, limiting the variability to 1.5x the *average* concentration of the mixture is not based on intruder protection. Rather, individual pieces that are averaged as part of a mixture need to be constrained around the classification limit to protect the intruder.

3. Cartridge Filters**:**

   a. One commenter stated that cartridge filters are physically, chemically, and radiologically more like DAW and should be treated as homogeneous wastes in the same context as DAW. Currently, the BTP treats them the same as activated metal. The commenter supported their argument with the following statements:

      - Cartridge filters account for a comparatively small volume and activity contribution to the overall source term.

      - Achieving disposability through processing has little impact on disposal site risk or in the total activity received.

      - Total annual activity generation for all cartridge filter accounts for only about half of the amount of activity annually disposed of in Class A resins prior to the closure of Barnwell.

      - Disposal volumes of cartridge filters typically account for few hundred cubic meters (few thousand cubic feet) per year.

   Staff Response:

   [This response has been superseded in the May 2012 draft].

   The current version of the BTP does not denote cartridge filters as homogeneous; therefore, they are considered individual items that are subject to certain averaging constraints. Being individual items, Section 3.5 of the 1995 BTP requires cartridge filters be classified by dividing activity by weight or volume of the filter. Mixing of cartridge filters is permissible and concentration averaging is allowed using certain constraints that are applicable to non-homogeneous waste. It is also permissible to conservatively base the classification on the highest classification associated with any single filter.

   The distinguishing characteristic of homogeneous wastes is that their radionuclide concentrations are likely to approach uniformity in the context of reasonably foreseeable intruder scenarios. The staff believes this will not be the case with at least some cartridge filter designs. Some filters (e.g., pressurized water reactor (PWR) primary system filters) are much more durable in the disposal environment than others. These would most likely not degrade as quickly leaving the enclosed filter media, which should degrade like other homogeneous waste, unavailable for mixing with surrounding soil per the intruder scenarios. Based on observations of filters, the staff believes that the enclosure could continue to retain the filter media and radioactivity, thereby preventing the radionuclide concentrations from approaching uniformity, at least for some intruder scenarios. In addition, cartridge filters from reactor coolant systems, spent fuel clean-up, etc., are typically classified as Class B or C whereas the majority of DAW is classified as Class A. In intruder scenarios, the consequence of an encounter with a hot spot is greater with filters than with DAW. Staff has therefore determined that cartridge filters in general should continue to be classified using the existing guidelines. At the same time, the staff recognizes that some cartridge filters could likely be considered as homogeneous, i.e., that their radionuclide concentrations would become nearly uniform in the context of reasonably foreseeable intruder scenarios. In Section 3.9 of the [2011] revised draft BTP, the staff has added cartridge filters as one of the items that can be considered for alternative provisions under the BTP.

4. Definitions:

   a. Classification-Controlling Radionuclides

   One stakeholder noted that the “reporting purposes” caveat is missing from the definition of “classification-controlling” in the Sandia draft and should be added. According to the commenter, nuclides that are classification-controlling should be those in which the activity of that nuclide in one or more components in the averaging groups exceeds the class limit so that it would actually be subject to averaging to meet the class limits.. Another commenter stated that, for the definition of “classification-controlling radionuclides,” the definition should be expanded to recognize that not only should a radionuclide be >1% of its applicable table value to be considered classification-controlling but should also be present in a relative fractional abundance such that the concentration of the individual radionuclide (or a combination of controlling radionuclides) are the specific basis for transition from one waste class to another. The commenter stated that this is the only means by which a generator can determine if the factor of 1.5 or 10 will be applicable in a concentration averaging scenario.

   Staff Response:

   [This response has been superseded in the May 2012 draft].

   The NRC agrees that the definition should be expanded to recognize that not only should a radionuclide be >1% of its applicable table value to be considered classification-controlling but should also be present in a relative fractional abundance such that the concentration of the individual radionuclide (or a combination of controlling radionuclides) are the specific basis for transition from one waste class to another. Appropriate changes have been made to the text of the BTP.

   b. Blending and Dilution

One commenter stated that there is a need to define or distinguish between “blending” and “dilution,” and to specify the conditions under which “dilution” is acceptable. These terms should first be defined in the BTP, and later in a Part 61 rulemaking. The commenter also believes that the BTP should discuss potential for introduction of other uncontaminated materials (such as stabilization reagents, coal combustion products, or other process additives) that may be added in the waste treatment or blending process, and should provide guidance on whether the volume of uncontaminated materials may be considered in waste classification calculations. Finally, the commenter believes that the BTP should ensure that waste treatment doesn’t change the waste characteristics such that Resource Conservation and Recovery Act (RCRA) materials are produced.

Staff Response:

The current version of the BTP specifies conditions under which non-radioactive materials may be considered for concentration averaging. For example, sealed sources may be encapsulated in concrete in a 0.2 m^3 (55 gallon) drum and the activity averaged over the volume of the drum. The circumstances under which non-radioactive materials are relied on for concentration averaging are limited in the BTP. The staff has not added a definition of dilution to the BTP, since staff interprets dilution, in the context of LLRW blending and the BTP, to mean the mixing of clean materials with contaminated materials, including liquids and gases, and release to the general environment, and these topics are not within the scope of the BTP. The scope of the BTP is narrow, and the conditions under which non-radioactive materials can be used in averaging are well-defined and limited. The BTP states that extreme measures should not be taken to lower the classification of the waste in stabilizing wastes to meet the 10 CFR § 61.56 requirements, for example. As a result of the comment, the staff has also added language that states that process additives during waste treatment should have a purpose in treatment other than reducing the concentration of the final mixture, and that extreme measures should not be used to lower the waste classification. With respect to blending, the staff has added a definition of blending to the BTP, consistent with the definition provided in SECY-10-0043, “Blending of Low-Level Radioactive Waste.” Blending of certain wastes is within the scope of the BTP. With respect to defining these terms in a rule, the staff will consider whether blending should be defined in its its site-specific analysis (SSA) rulemaking to require a site-specific analysis for intruder protection. Blended wastes are within the scope of that rulemaking. With respect to the term “dilution,” if NRC makes comprehensive revisions to 10 CFR Part 61 at a later date, the staff will consider whether this term should be defined in that rulemaking. Defining the term will depend in part on the scope of the potential revisions, which are not known at this time.

With respect to the comment regarding hazardous waste and RCRA, the commenter did not provide a reason for adding language regarding RCRA to the BTP. Absent any specific concern, a licensee is always responsible for meeting the requirements of RCRA any time a RCRA material is introduced into its process, and is subject to enforcement if it does not. The staff does not believe that RCRA needs to be addressed in the BTP given that there are regulations in place that would apply to any waste treatment activities involving hazardous materials.

c. Homogeneity

One commenter stated that the definition of homogeneity in the Interim Guidance is vague. (The staff issued Interim Guidance on LLRW blending to the Agreement States on March 17, 2011).[14] The guidance addresses how Agreement States can review proposals for large-scale blending). The commenter recommended that the NRC include a more robust definition that includes measurable parameters.

Staff Response:

The revised BTP defines homogeneous waste as waste in which the classification-controlling radionuclide concentrations are likely to approach uniformity in the context of reasonably foreseeable intruder scenarios. This definition is performance-based and does not include specific measureable parameters because the range of reasonably foreseeable intruder scenarios is expected to be site-specific. However, the NRC expects that a well-drilling scenario, as described in Appendix B of the revised BTP, is likely to be reasonably foreseeable under many different disposal conditions. A well drilling scenario also is expected to impose greater constraints on waste homogeneity than a scenario in which more waste is exhumed (e.g., dwelling construction) because the exhumed waste will be mixed over a smaller volume as it is exhumed. Based on this well-drilling scenario, the revised BTP provides guidance on certain measurable parameters that are expected to be sufficient to demonstrate homogeneity. Specifically, the guidance recommends that licensees intentionally blending waste during waste processing demonstrate that the as-disposed waste does not have sub-volumes of waste greater than 0.03 m^3 (1 ft^3) that exceed 10 times the relevant class limit. Different means of demonstrating homogeneity may be appropriate under different site-specific conditions.

[Note—the May 2012 draft increased recommended sub-volume limit from 0.03 m^3 (1 ft^3) to 0.15 m^3 (5 ft^3)].

d. Homogeneous Waste

One commenter noted that the homogeneous waste definition can be applied to a single, as-generated waste type as described in the current BTP or the resulting waste from a combination of physically similar types, of similar radionuclide relative fractional abundance but dissimilar radionuclide concentrations.

Staff Response:

The NRC agrees that the term "homogeneous waste" can be applied to a single, as generated waste type designated as "homogeneous" in the BTP (i.e., solidified liquid, spent ion-exchange resins, filter media, evaporator bottom concentrates, contaminated ash, contaminated soil, and containerized DAW) or to a mixture of wastes that has been demonstrated to be homogeneous. Homogeneous waste types are discussed in Section 3.2 of the revised BTP [Section 4.2 in the May 2012 draft]. Methods for demonstrating

[14] See ADAMS ML110480839 and ML110480850.

the homogeneity of a mixture of homogeneous waste types are discussed in Section 3.2.1 [Section 4.2.2.2 in May 2012 draft].

e. Homogeneous Waste Type (in the Sandia draft)

One commenter stated that the definition of homogeneous waste should continue to apply to as-generated waste types such as spent resins, flowable filter media, solidified liquids, evaporator concentrates, contaminated soil, and containerized DAW. The commenter suggested that, as in earlier BTP documents, the only wastes excluded from this definition would be activated hardware and potentially cartridge filters, depending on the source of generation, processing applied, and packaging.

Staff Response:

The revised BTP continues to designate certain waste types (i.e., solidified liquid, spent ion-exchange resins, filter media, evaporator bottom concentrates, contaminated ash, contaminated soil, and containerized DAW) as homogeneous waste types. Solidified liquid is considered a homogeneous waste type because radionuclide concentrations are expected to be uniform at the time of disposal. Spent ion-exchange resins filter media, evaporator bottom concentrates, ash, and contaminated soil are considered a homogeneous waste type because they are flowable, and the radionuclides in these waste streams are expected to be uniformly distributed when exhumed under reasonably foreseeable intruder scenarios. DAW, which may be composed of a variety of miscellaneous materials, may be considered a homogeneous waste type for purposes of waste classification when placed in containers because it is expected to degrade within approximately 100 years to a more soil-like state in which it will be mixed if exhumed by an intruder. In each case, additional averaging of an intruder's exposure to the waste is expected to occur by the natural movement of the intruder around the site, even if waste is not completely mixed as it is exhumed and spread on the surface.

Other waste types that are not considered homogeneous include activated hardware, sealed sources, contaminated items that are not disposed of as containerized DAW, and cartridge filters.

[Note—cartridge filters could be classified as homogeneous waste in the May 2012 draft, provided certain criteria are fulfilled].

f. Component and Item

One commenter requested that the terms "component" and "item" as used in the Sandia draft be clarified. "Item" implies that a cut up component needs to be classified individually, apart from its original classification when part of the component. Another commenter, in addressing Section 7 of the Sandia draft, "Classifying individual items," stated that this section should be retitled, "Classification of Irradiated Components and Associated Cartridge Filters" and be comprised of the entire content of Section 3.3 of the original 1995 BTP, including Figure 1. The commenter stated that it was critically important that the definition of "component" described in the 1995 BTP be retained for purposes of concentration averaging and that re-characterization of sub-pieces that result from sectioning of the larger component for packaging efficiency not be required. Such an interpretation would result in orphaned waste and is completely contrary to the original intent and purpose of the 1995 BTP, according to the commenter. The "piece" rule (0.01 cubic feet) contained in Section 3.3.2 [now Section 4.3.2] of the original BTP was designed specifically to address those situations where individual pieces may require separate consideration for classification purposes.

Staff Response:

The staff agrees that the draft of the BTP that was made available for public comment omitted the 1995 BTP's policy that allows a larger "component" to be cut into pieces, and still be classified based on the classification of the original component, provided the pieces of the component meet certain criteria. The BTP text has been revised to include the 1995 policy on classifying larger components that are sectioned. Also, what was previously titled Section 7 in the draft BTP that was made available to the public has been renamed "Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters," which is similar to the commenter's recommendation.

g. Heterogeneous Waste Mixture

One commenter stated that the term "heterogeneous waste mixture" should be revised to better define "reasonably similar" radionuclide concentrations. Assuming wastes originate from different sources and contain dissimilar radionuclide concentrations but similar relative fractional abundance, then the mixture of materials could reasonably approach uniformity in the context of the intruder scenario, according to the commenter. It would be more appropriate to define heterogeneity as a function of differing radionuclide concentrations of classification-controlling radionuclides present in each portion of the overall waste mixture. Application of the factor of 10 to the average would be an appropriate control to impose on mixtures of materials with differing relative radionuclide concentrations.

Staff Response:

[This response has been superseded by the May 2012 draft].

The staff agrees that the use of this phrase was not clear. The phrase "heterogeneous waste mixture" has been removed, and replaced with the phrase, "Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters." The NRC also agrees that heterogeneity should be based on classification-controlling radionuclides and the BTP has been revised accordingly.

h. Encapsulation

A commenter suggested that the term, "encapsulation" be defined in the BTP and suggested the following definition of "encapsulation" be added to the BTP--"The process of surrounding a discrete radioactive source, or collection of discrete sources in an approved binding matrix, within a container, where the activity remains within the geometric dimensions of the source(s), thereby providing additional separation from the environment and an additional and readily recognizable waste form with regard to potential inadvertent intrusion."

Staff Response:

The staff agrees and a definition of encapsulation has been added to the BTP.

i. Solidification

The same commenter that asked that "encapsulation" be defined, suggested that the following definition of "solidification" be added to the BTP--"The process of incorporating radioactive material in an approved binding matrix, in a manner to achieve homogeneity within a container, where the activity is distributed throughout the final monolith thereby providing additional separation from the environment and an additional and readily recognizable waste form with regard to potential inadvertent intrusion."

Staff Response:

The staff agrees and a definition of solidification has been added to the BTP.

j. Discrete Item

One commenter stated that the term, "discrete item" should be reserved for individual contributions to a waste package where the higher radionuclide concentration within the item has the potential to vary from the average concentrations within other items or contributions to the package by more than a factor of 10. This would generally apply to activated hardware and sources.

Staff Response:

For consistency and clarity, the staff uses the term "individual item" throughout the BTP when referring to a single piece or item. The Sandia draft of the BTP had used the terms interchangeably. Individual items may be averaged as part of a mixture, or may require separate classification (in accordance with Figure 2), depending upon their characteristics.

k. Contribution or Contributor

One commenter stated that the term, "contribution" or "contributor" to the overall waste package would be an appropriate means to distinguish between separate volumes of resins, batches of concentrates/liquids, cartridge filters or batches of contaminated materials from differing generation sources for purposes of evaluation of heterogeneity/homogeneity of the total waste package during classification.

Staff Response:

The staff agrees, in general, and "contributor" is used to describe the contributors to a mixture from different origins.

5. BTP Should be an Interim Guidance Document:

   a. Several stakeholders stated that the BTP should be an interim measure, either until the site-specific analysis (SSA) rulemaking or the more comprehensive Part 61 revision is completed. One commenter stated that the BTP should be kept in place until the "Part 61 revision process" is completed [the "Part 61 revision process" includes an ongoing SSA rulemaking, and potentially a more comprehensive revision to Part 61 at a later date]. Another stakeholder believes that the BTP should be eliminated after the site-specific analysis rule is completed, since both deal with intruder protection and the rulemaking can suffice for that purpose.

      Staff Response:

      The Commission approved the SSA rulemaking in the staff requirements memorandum for SECY-08-0147, "Analysis of Depleted Uranium." One of the purposes of the rule is to require that a site-specific analysis be conducted to demonstrate protection of an inadvertent intruder, rather than relying solely on the waste classification system and other existing 10 CFR Part 61 requirements. Longer term, the Commission, in its staff requirements memorandum for SECY-08-0147,[15] requested that the staff consider more comprehensive revisions to 10 CFR Part 61. In SECY-10-0165, the staff identified five potential options for such comprehensive revisions, and outlined an approach for obtaining additional stakeholder views on such a rulemaking. The staff committed to providing the Commission with an analysis of public comments on the options and a recommendation by the end of 2012.

      [Note—the Commission has given the NRC staff revised direction on comprehensive revisions to 10 CFR Part 61 in its January 19, 2012, "Staff Requirements Memorandum–COMWDM-11-0002/COMGEA-11-0002 – Revision to 10 CFR Part 61." (ADAMS Accession No. ML120190360)]

      With respect to the SSA rulemaking, which is ongoing, its final provisions and scope will not be known until it is completed. Thus, whether the final rule will affect guidance provided in the BTP is not known at this time. The NRC is coordinating the development of the BTP revisions with the SSA rulemaking. The staff will evaluate impacts to the BTP and whether any revisions to the BTP are necessary after the SSA rulemaking is completed. The NRC believes that as long as the waste classification tables in 10 CFR § 61.55 are applicable to generators and disposal sites, some limits on averaging will be necessary in order to demonstrate compliance with the class limits.

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[15] Commission Staff Requirements Memorandum for SECY-08-0147, "Response to Commission Order CLI-05-20 Regarding Depleted Uranium, March 18, 2009. ML090770988.

6. Relationship Between BTP and the SSA Rulemaking:

   a. One commenter noted that the SSA rulemaking will allow for the development of site-specific waste acceptance criteria which can eliminate the need for classifying waste shipped from a generator and the waste classification tables in 10 CFR Part 61. Another commenter requested that the BTP address the radiological risks to an intruder encountering waste at the upper end of Class A limits. The same commenter recommended that a site-specific intruder analysis be conducted to address intruder risks, and the need for additional controls, such as deeper burial. The commenter specifically requested that the BTP discussions be broadened to include risk-informed methods to demonstrate intruder protection.

      Staff Response:

      As noted above, NRC already has underway a SSA rulemaking that was approved by the Commission in the staff requirements memorandum for SECY-08-0147, "Analysis of Depleted Uranium." One of the purposes of the rule is to require a site-specific analysis to demonstrate protection of an inadvertent intruder. Additional controls for a disposal facility might be required from the analysis conducted. However, the waste classification tables will continue to apply to generators and disposal facilities after the rulemaking is completed, and guidance covering acceptable averaging approaches under 10 CFR § 61.55(a)(8) will be needed. [Note— the Commission has given the NRC staff revised direction on comprehensive revisions to 10 CFR Part 61 in its January 19, 2012, "Staff Requirements Memorandum– COMWDM-11-0002/COMGEA-11-0002 – Revision to 10 CFR Part 61." (ADAMS Accession No. ML120190360). The provisions of the final rulemaking may make this response obsolete.]

      With respect to risks associated with disposal of blended waste at the upper end of the Class A limits, protection of the intruder from these risks is addressed in Appendix B, "Technical Basis for Concentration Averaging and Encapsulation Guidance." Based on the analysis, NRC has recommended constraints on homogeneity which are incorporated into Section 3.2.2 of the BTP [Section 4.2.2.2 of May 2012 draft].

      With respect to the expanding the scope of the BTP to include site-specific intruder analysis considerations, the scope of the BTP is generic and for the classification of mixtures of items and encapsulation of sources in accordance with 10 CFR § 61.55. See response to item 7 below for additional information.

      [Note—the May 2012 draft has included site-specific considerations for averaging in the Section 4.9, "Alternative Approaches."]

7. Use of Site-Specific Intruder Analysis in Lieu of BTP:

   a. Several commenters felt that site-specific intruder analyses could be used to protect an inadvertent intruder and would eliminate the need for the BTP averaging provisions. They asked that the BTP provide guidance on site-specific intruder protection (a NUREG-1854 approach). Another stated that if additional controls or barriers are needed to protect the intruder, additional engineering analysis may also be needed to ensure that the controls or barriers will not degrade or fail to perform for as long as the radiological consequences are unacceptably high. The commenter encouraged NRC to broaden the discussion in the BTP of using risk-informed methods to demonstrate intruder protection, addressing site-specific performance assessments, the development of site-specific waste acceptance criteria (WAC) and site-specific averaging provisions. According to the commenter, such an approach would harmonize LLRW regulations at NRC with DOE program and its Waste Incidental to Reprocessing program.

Staff Response:

The NRC agrees that site-specific intruder analyses could be used to demonstrate protection of the inadvertent intruder. However, the staff believes there is value for generators and processors in maintaining a BTP that provides "generic," look-up guidance for the classification of mixtures of items and encapsulation of sealed sources in accordance with 10 CFR § 61.55. When a licensee performs a site-specific analyses, the licensee can review the section titled, "Alternative Approaches for Averaging" in the BTP which describes in detail how a site-specific intruder analysis might be used to justify higher limits based on such factors as waste form and site characteristics and depth of burial. With respect to eliminating the need for the BTP, see response to comment 6.a.

b. For material licensees generate small quantities of thousands of radwaste forms, it would be impractical to perform site-and waste-specific assessments for all waste forms.

   Response:

   Materials licensees can continue to classify and ship waste in accordance with the basic positions in the BTP, without relying on site- or waste-specific assessments. There is no requirement that licensees perform these types of assessment. Disposal facility operators may wish to perform these assessments in order to allow for different wastes to be accepted for disposal at their facilities.

8. Scenario Selection for Inadvertent Intruder:

   a. A commenter stated that the NRC should not postulate scenarios different from those in the Draft Environmental Impact Statement (DEIS) technical basis for Part 61, especially the new "driller" and "intruder handling" scenarios. If a drilling scenario is postulated and used as a basis for averaging constraints, it should be realistic. Specifically, the commenter noted, if the driller encounters a solid block of concrete, drilling would be stopped. If a driller encounters a source, credit should be allowed for soil above and below the source.

      Staff Response:

      The inadvertent intruder performance objective in 10 CFR § 61.42 states that the disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed. While the waste classification tables in 10 CFR § 61.55 were based on generic scenarios analyzed in the DEIS, there may be instances in which other reasonably foreseeable intruder scenarios could occur, such as drilling or handling of individual items, that could affect intruder protection. With deeper disposal, as is common practice today, the DEIS scenarios may not be that applicable for the intruder, because the depth of disposal of waste is deeper than the home foundation postulated in the DEIS. In these cases, postulation of well drilling, as a reasonably foreseeable event under a variety of site conditions, is appropriate to ensure continued intruder protection. Further, the Commission (in SRM-SECY-10-0043) directed the staff to consider homogeneity in the context of reasonably foreseeable intrusion scenarios. The staff agrees that credit should be allowed for mixing soil with radioactive materials, both above and below the radioactive source in the drilling scenario. The drilling scenario used as the basis for the homogeneity guidance in this revised BTP did include mixing with soil above and below the waste.

With respect to the intruder "handling" scenario, after the finalization of Part 61, there were a number of accidents involving small, highly radioactive sealed sources. The nature of these accidents led NRC to consider individual gamma-emitting items that might survive in a LLRW disposal facility and their radioactive nature not be recognized by an inadvertent intruder. To ensure that individual gamma-emitting items do not compromise the protection of the inadvertent intruder, the 1995 BTP introduced exposure scenarios that assessed the possible dose consequences to an inadvertent intruder unknowingly handling a recognizable LLRW item 500 years after disposal. While the DEIS postulated that an intruder could be exposed to individual items, it was for a limited period of time, resulting in low exposures to radioactivity.

With respect to a driller ceasing activities upon encountering concrete, the staff positions in the BTP are conservatively based on radioactive material not being surrounded by concrete. However, if a specific site has concrete vaults in its design, or other concrete barriers, it may be appropriate to assume that drilling is stopped when the concrete is reached. The licensee should consider the effect of reasonably foreseeable processes on the degradation of the vault's mechanical properties that would be relied upon to limit access to the waste. Some of these processes, which are site-specific, may include seismic activity, cementitious material degradation such as acid leaching or corrosion of the reinforcing steel. The licensee or applicant should also consider local drilling practices and estimate when currently used technology would likely penetrate the vault given its estimated degradation of mechanical properties. For instance, the likelihood of breaching the concrete vault would likely occur earlier in regions of the country where hard-rock drilling is common compared to regions where hard-rock drilling is not common. These justifications could be considered in an alternative approaches analysis described in Section 3.9 [now Section 4.9] of the BTP. The drilling scenario used as the basis for the homogeneity guidance did not assume the individual would drill through concrete.

9. Sealed sources:

   a. Maximum Size of Sources for Disposal:

Several commenters noted the significant constraints that the current BTP recommends for sealed sources, especially Cs-137 sources. If a source is encapsulated in concrete in a 55 gallon [0.2 m^3] drum, the maximum Cs-137 source size is 30 Ci [1.1 TBq]. If the source were averaged over the volume and the Class C limit used, the maximum source size would be 920 Ci [4.8 TBq]. Commenters asked that this recommended limit be re-examined and raised. In a related matter, one commenter asked that the basis for whatever limits the BTP recommends be clear. The current BTP was developed in part to address Goiania type events, but this is not clear from the text in the BTP. Goiania was a significant safety event in Brazil in 1988 involving a sealed radioactive source being inadvertently handled by members of the public.

Staff Response:

The NRC agrees and staff completed an extensive review of the basis for the 30 Ci [1.1 TBq] limit for Cs-137 in the 1995 BTP. The NRC's review included an analysis of the basis for the 1995 policy and an analysis of accidents involving sealed radioactive sources, and a review of approaches used by other countries to regulate disposal of sealed sources.

Based on the results of this extensive review, NRC finds it is appropriate to set limits on disposal of highly-radioactive items that could survive intact in a LLRW landfill, and not be recognized as being hazardous. After the review, the NRC revised the scenario-basis for the encapsulation policy and used a more realistic "gamma sealed source carry away scenario." Using the new scenario, the limit for disposal of encapsulated Cs-137 sealed sources has been raised. Also the revised BTP addresses how higher limits might be justified for Cs-137 and other nuclides. Finally, the revised BTP clarifies that there are no intruder-based limits for Class B or C disposal of Co-60 sealed sources.

b. Use of Other Protective Measures to Increase Source Size:

Several commenters asked that the BTP acknowledge that other measures might be used to increase the size of sources acceptable for disposal. For example, NRC should provide guidance on engineered controls to protect an intruder, since the intruder "discovery" scenario does not provide sufficient protection. These engineered controls could include concrete canisters and disposal at greater depth. Another commenter noted that the BTP could allow credit for shielding during disposal to limit doses to an inadvertent intruder. Credit for shielding other than concrete (lead, depleted uranium, and tungsten) could be acknowledged in the BTP. A related comment was that sources are often contained in transfer shields and the BTP should allow for encapsulation of larger activity sources contained within their transfer shields (or equivalents) such that activity can be averaged over the encapsulating mass up to the applicable waste class limits for the specific source radionuclide. The commenter stated that the combination of shield and encapsulation media can provide sufficient barrier to the inadvertent intruder under the discovery or construction scenarios and the addition of the transfer shield should be sufficient to prevent access in a well drilling scenario.

Staff Response:

The revised BTP provides a new section titled, “Alternative Approaches for Averaging,” which describes in detail how a site-specific intruder analysis might be used to justify higher limits based on waste form and site characteristics and depth of burial. Long-lived shielding and depth of burial are two factors cited in the revised BTP that might provide site-specific justification for higher limits.

c. Package Size Limit for Sources:

A commenter asked that NRC increase the package size limit from 0.2 m^3 (55 gallons) so that sources in shields can be disposed of (these are too large to fit into 0.2 m^3 (55 gallon) drums).

Staff Response:

The staff agrees. The revised BTP states that “for determining the classification of an encapsulated source (or multiple sources in a single container), the maximum volume or mass should be 0.2 m^3 or 500 kg. *For physically encapsulating a single source, the volumes and masses may be larger than 0.2 m^3 or 500 kg to allow for disposal of a sealed source in its shielded housing and/or source device*. The shape of the final encapsulated package does not have to be a cylinder.”

d. Encapsulation of Multiple Sources:

One commenter suggested a revision to Section 9, Item (2) of the Sandia draft—that the last sentence read “Encapsulation of multiple sources in a larger volume is acceptable so long as the maximum .2 cubic meters (55 gallons) of encapsulate per discrete source is retained and all other requirements of this section are met.”

Staff Response:

The staff agrees and the revised BTP allows encapsulation of multiple sources in a 0.2 m^3 (55 gallons) encapsulated volume.

e. Alternative Provisions for Sealed Source Disposal:

One commenter stated that if NRC does not incorporate its suggestions for sealed sources, the BTP should elaborate on “generally acceptable” practices and bounding conditions, as well as additional guidance on the anticipated or expected content of a request for approval for alternative provisions for classification and disposal.

Staff Response:

The revised BTP includes a new section titled, “Alternative Approaches for Averaging,” which describes in detail how a site-specific intruder analysis might be used to justify higher limits based on waste form and site characteristics and depth of burial.

10. Volume for Averaging:

a. One commenter stated that heterogeneity should be considered in context of averaging volume (e.g., home foundation). Waste should be assumed to be evenly mixed, and container non-uniformity does not affect long-term risk. Another commenter felt that the BTP should allow for averaging over a volume greater than the container, and suggested that the use of a site-specific performance assessment and WAC should be the mechanism to define averaging and waste volumes. Such an approach could be used for large components that are cut up to facilitate transportation and disposal, as well as for wastes from the remediation of a decommissioned site.

   Staff Response:

   The NRC agrees that heterogeneity should be considered in the context of reasonably foreseeable intruder scenarios. With the modern practice of placing wastes many meters below the surface, a reasonable foreseeable scenario might be the well drilling scenario (and not the basement scenario). If the well drilling scenario is reasonable foreseeable, then sub-container heterogeneity might be important and not heterogeneity across multiple packages.

   If the wastes are near the surface, the intruder scenarios could involve waste volumes larger than the shipping container volume that is the basis for the positions in the BTP. As noted in Section 5 of this Appendix, a disposal facility operator could perform a site-specific intruder analysis and then specify waste acceptance criteria (WAC) for generators that would ensure that the assumptions regarding the waste form, class, concentration, nuclides, etc. were consistent with the assumptions in the analysis conducted for intruder protection. The WAC could address such areas as concentration limits, waste form, packaging, physical and chemical forms, paperwork required, etc. The WAC could also include constraints on averaging as well, based on the site-specific analysis. However, as long as the 10 CFR § 61.55 tables remain in Part 61, generators will have to demonstrate compliance with them before they make shipments to a disposal site, and using appropriate averaging approaches should be useful for demonstrating compliance.

   The NRC agrees that in many cases, waste can be assumed to be evenly mixed after it is exhumed. Even if waste is not perfectly homogenized during exhumation, natural movement of an intruder around the site would be expected to average their exposure. NRC expects a well-drilling scenario would be reasonably foreseeable under many different disposal conditions. For some waste types, such as sealed sources or activated metals, there may not be mixing of the waste with soil. The BTP specifies averaging positions based on the Appendix B technical bases for these wastes that retain their form over long periods of time.

   Container non-uniformity could affect an intruder exhuming a small amount of waste (e.g., a well driller) in certain waste configurations (e.g., if vertically-aligned features of high concentration exist). Waste stratification into even layers is not expected to affect an intruder. For stratification to affect dose, an intruder would need to exhume only the layers of waste in a disposal container that have the greatest radionuclide concentration. While possible (e.g., if dwelling construction disturbed only the top half of a layer of waste containers and all of the higher-concentration waste had risen to the top of the containers), this scenario is expected to be unlikely and is not considered to be reasonably foreseeable.

With respect to large components that are cut up and remediation wastes, the scope of the BTP includes wastes that are in containers. While the staff agrees that averaging of large components and separate shipments of remediation waste at a disposal facility could be considered in a site-specific assessment, the shipper would need to demonstrate compliance with the waste classification provisions currently in 10 CFR § 61.55.

11. Other:

a. Treatment of Sealed Sources and Activated Metals should not be the same:

One commenter stated that BTP should not treat sealed sources the same as activated metals and other discrete reactor items. The commenter noted that activated metals, cartridge filters, and contaminated items are subject to factors of 1.5 and 10 constraints on averaging. Sealed sources are allowed credit for a 23 fold reduction in concentration through encapsulation, so the BTP is not consistent.

Staff Response:

The revised BTP used two scenarios to define positions for protecting the intruder from hot spots. One scenario is appropriate for small (sealed source) items that could be placed in a pocket, and the other scenario is appropriate for larger pieces that would require equipment to move. The sealed source scenario involves 4 hours of exposure in a coat pocket at a distance of 1 cm (0.39 in). The larger pieces scenario involves exposure at 15 cm (5.9 in) for 21 minutes. The two scenarios result in different BTP policies and it would be inappropriate to apply the sealed source scenario (with 1 cm exposure distance for 4 hours) to large pieces of metal. However very small pieces of activated metal may be sealed-source like and those pieces should continue to be identified (using Table A) and managed separately.

b. Consideration of "Likelihood" of Intrusion in BTP:

One commenter believes that NRC should assume a probability of one for the intruder. Another commenter noted that DOE allows for consideration of likelihood of intrusion. DOE has done it once so far and used expert elicitation. DOE Order 435.1, "Radioactive Waste Management," allows for credit for institutional controls of longer than 100 years and this was a factor in choosing a probability of less than one. Finally, another commenter felt that a probability of intrusion of less than one could be allowed in some cases. In particular, the commenter argued, it is not realistic to assume that a probability of intrusion is one immediately after the 100 years of institutional controls. These controls are likely to continue to be in place after 100 years.

Staff Response:

[This response has been superseded by the May 2012 draft].

The NRC notes that there is no scientific basis for quantitatively predicting the nature or probability of a future human activity. This is in contrast to a natural process for which a scientific basis may be developed to support a probability of occurrence. Therefore, an inadvertent intruder assessment typically does not consider the probability or likelihood of inadvertent intrusion occurring. Rather, the assessment assumes reasonably bounding scenarios (conservative, but not overly conservative scenarios) that could occur and evaluates the radiological consequences that could be experienced by individuals who might actually intrude onto the disposal site should active and passive controls fail, societal memory be lost and the site be unrecognizable as a disposal site. In this approach, the staff assumes intrusion occurs and examines the consequences rather than truly evaluating the risk (consequence x probability).

The staff has addressed likelihood of intrusion in a new section of the BTP titled, “Alternative Approaches for Averaging.” In this section, the staff recognizes that there may be circumstances in which likelihood of intrusion can be considered, with other factors, in justifying averaging approaches different from those specified in the BTP.

It should also be noted that NRC has acknowledged a reduced likelihood of exposures to inadvertent intruders (see, e.g., 59 FR 17052, “New England Coalition on Nuclear Pollution, Inc.; Denial of Petition for Rulemaking). In addition, the intruder dose limit is 0.5 mSv/yr (500 mrem/yr) instead of 0.25 mSv/yr (25 mrem/yr)– essentially acknowledging a 5% probability for intrusion. For the Class C limits, probability was one of several factors used to justify increasing the Class C limits by a factor of 10. [Note—in Section 4.9.4 of the May 2012 draft, the staff has clarified that the probability of intrusion implicit in the Denial of Petition for Rulemaking discussed in this response is 20%, based on a comparison with the 1 mSv/yr (100 mrem/yr) public dose limit. The staff also indicates the implicit probability of intrusion may be interpreted to be 5%, based on comparison with the 0.25 mSv/yr (25 mrem/yr) dose limit for protection of the general population from releases of radioactivity in 10 CFR § 61.41.]

c. Initial Waste Classification:

One commenter stated that in the Sandia draft of the BTP, issued with the Federal Register notice requesting comments on the BTP (76 FR 4739), the concept of an “initial waste classification” is inconsistent with concept of waste classification in the regulations. The regulations, in 10 CFR Part 20, Appendix G, require classification at the time of shipment for disposal. The commenter stated that the BTP should call this initial description something else, e.g., “Initial characterization.”

Staff Response:

The staff agrees that waste must undergo characterization first; the waste is then classified based on its characteristics. The term, “initial waste classification” has been replaced with “waste characterization.” Waste is not required to be classified in NRC’s regulations (10 CFR Part 20, Appendix G) until it is ready for disposal. Thus, use of this term “classification” to describe wastes that are not yet packaged for disposal is inconsistent with the regulations.

The concentration of different LLRW forms generated at licensed manufacturer facilities are quantified with a range of precision. Typically heterogeneous wastes such as building rubble from decommissioning and laboratory trash can be difficult to quantify and the tendency is to over estimate. However, this waste usually contains very little radioactivity. Most of the radioactivity in manufacturer’s LLRW is in disposed radiochemicals and sealed sources that can be assayed very accurately, well within a factor of 2. However, when it is necessary to divide this radwaste between multiple containers to meet burial and/or transportation requirements, the quantity in each container is likely to be estimated with less precision that the total quantity. This is probably not significant if these containers are placed together in the disposal site. If the disposal site model assumes the inadvertent intruder to be exposed to the average concentration of multiple containers it might be better to use the more precise estimate for the total activity.

d. Greater-Than-Class-C Waste (GTCC):

One commenter stated that GTCC waste should be classified at the time of shipment, like other waste classes. Another stated that if new BTP positions make it so hard to dispose of waste, industry may concentrate it and make it a Federal responsibility.

Staff Response:

The BTP is consistent with the existing regulations for LLRW classification, which do not require waste to be classified until it is ready for shipment. In the Commission decision on LLRW blending (SRM-SECY-10-0043), the Commission directed the staff to not include GTCC concentrations in the scope of the ongoing SSA rulemaking, which will address in part blended LLRW. The Commission noted in the SRM that GTCC waste is a Federal responsibility and should not be made into a State responsibility, even if the waste has been blended into a lower classification.

e. Heterogeneity:

One commenter stated that there is no need to provide guidance on this issue for most waste forms. Other than wastes that retain their form over an extended period of time, the others become homogeneous over time and when mixed by the intruder. NRC can address heterogeneity in the uncertainty portion of a site-specific analysis. NUREG-1854 already has guidance that can be used here. For discrete sources, allow averaging over packages.

Staff Response:

The staff has addressed the relationship between a site-specific analysis and the BTP in Sections 5, 6, and 7 of this Appendix. NRC agrees it would be appropriate to address waste heterogeneity in the uncertainty portion of a site-specific intruder analysis. Homogeneity guidance is provided in the revised BTP because the "factor of 10" rule on mixing wastes was eliminated. Without some guidance on final waste form heterogeneity, extremely concentrated wastes could be disposed of as Class A waste, if the disposal container is large enough. Specifically, the guidance has two purposes:

- To protect an intruder who exhumes a small amount of waste (e.g., a well driller) from hitting a pocket of waste far exceeding the class limits that has been mathematically averaged to meet the class limits.

- To provide guidance to processors engaged in intentional blending on when the waste has been sufficiently mixed.

f. Basis for Table B is not clear in BTP:

One commenter stated that the basis for Table B, which defines the maximum size of components of non-primary gamma-emitting items, is not clear.

Staff Response:

NRC agrees and the revised BTP addresses the basis of the Table B values. They are derived from the concentration limits for each waste class and radionuclide for waste contained in a 0.2 m^3 (55 gallon) drum.

g. Performance-Based License Conditions:

One commenter requested that the BTP provide examples of performance-based license conditions.

Staff Response:

The purpose of the BTP is to address a wide variety of waste types and averaging concerns for LLRW, to ensure that the waste classification requirements in 10 CFR § 61.55 are met, and to protect an inadvertent intruder into a disposal facility. Most disposal facility licenses reference the BTP as a whole in a license condition.

Performance-based criteria have the following attributes: (1) measurable, calculable or objectively observable parameters exist or can be developed to monitor performance; (2) objective criteria exist or can be developed to assess performance; and (3) licensees have flexibility to determine how to meet the established performance criteria in ways that will encourage and reward improved outcomes. With respect to the first two criteria, many of the positions in the BTP could be converted to performance-based license conditions. Homogeneity criteria, and the limits on variability of waste concentrations are two examples. With respect to the third criterion, licensees could submit license amendments requests to approve alternative approaches, as described in Section 3.9 [now Section 4.9] of the BTP. Another performance-based approach to averaging would be to conduct a site-specific intruder analysis, as discussed in Section 3.9 [now Section 4.9] of the BTP. However, as noted in these sections, this approach is currently limited in its usefulness for averaging because of the need for a generator to classify waste before shipping to a disposal facility.

h. Concentration of Waste:

One commenter stated that NRC should require licensees to concentrate waste as much as possible. In his view, it is better to have smaller and more concentrated volumes.

Staff Response:

In 1981, NRC published a Policy Statement that encourages licensees to volume reduce their LLRW. This document is a policy statement, not a regulation, and therefore licensees have flexibility in deciding whether to volume reduce their waste. Because of the high cost of waste disposal, licensees have achieved substantial volume reduction since the policy statement was issued. The staff does not believe that it is desirable to require licensees to concentrate their waste as much as possible. If NRC were to require waste volume reduction to the greatest extent possible, most LLRW would not have a disposal option, because waste would likely be concentrated to Greater-Than-Class C (GTCC) and would have to be stored until a GTCC disposal facility is developed, which is not expected for many years. Such a policy would thwart disposal of waste as Class A, B, or C, an undesirable outcome since disposal is the preferred option for waste, over storage. NRC is currently revising its Volume Reduction Policy statement to specifically recognize that other factors may be considered in licensees decisions on whether to volume reduce their waste or not.

i. Introduction to Sandia Draft:

One commenter cited a statement in the draft Sandia BTP, "This 61.55(a)(8) requirement applies to packages of reasonably homogeneous waste" and noted that the stated limitation is not in the regulation. The commenter noted that one can argue that the BTP authors may have had that in mind, but that's not stated or implied in the regulation. The commenter appears to be implying that the statement should be deleted.

Staff Response:

The staff agrees that the 10 CFR § 61.55(a)(8) requirement was not written specifically for individual waste packages, and the sentence has been removed. The BTP, however, recommends certain constraints on averaging, as noted by the commenter.

j. Removal of Items from Container:

One commenter stated that text in Paragraph 2 of Section 3 of the Sandia draft, and the attendant flow charts, introduce a limitation on the concentration averaging process that was not intended by the original version of the 1995 BTP. In the commenter's view, requiring the removal of higher concentration contributors to the overall package is completely contrary to the intent and concept of the 1995 BTP. The commenter believes, rather, the demonstration that a specific collection of wastes within the container that meet the averaging limitations such that the higher concentration contributors can be considered to meet the class concentration limits is the intent.

Staff Response:

In developing the BTP, the NRC was concerned that long-lived gamma hot spots might compromise the protection of the inadvertent intruder and some constraints on averaging needed to be specified. These recommended constraints allow for a demonstration that a specific collection of wastes within a container can have their concentrations averaged to meet the classification limits in 10 CFR § 61.55, and that some higher concentration contributors averaged with lower contribution contributors. At the same time, certain items that are outside of the constraints defined in the BTP should be identified and managed separately to ensure intruder protection.

k. Consolidation of Sections of the BTP:

One commenter stated that the consolidation of activated metals, contaminated materials and cartridge filters in the Sandia draft creates problems. The commenter stated that the draft Section 4 imposes terminology and limitations on all wastes that were specifically intended to address the significant variation in activity and concentrations associated with activated hardware. Section 3.3 (3.3.1-3.3.6) [now Section 4.3 and 4.3.1-4.3.3] including the flow chart Figure 1 of the original BTP lists the specific guidance to be applied to activated hardware. In the commenter's opinion, imposition of these criteria on other wastes is impractical and serves no benefit in terms of improved protection of the public or the environment. According to the commenter, relocation of Section 3.3 [now Section 4.3] in its entirety (including Figure 1) into Section 7 to the revised BTP will provide the specific guidance necessary to address activated hardware while allowing streamlining of the process for all other wastes, according to the commenter.

Staff Response:

The NRC carefully reviewed the guidance set out in the 1995 BTP for activated materials, contaminated material and cartridge filters and found the requirement to be all but identical for all three waste types and that applying one set of criteria to all three waste types was simple and appropriate. The staff believes this consolidation of these sections is an improvement to the document. The staff did not intend to effect changes to the original positions, only to make the BTP better organized and improve its readability. The staff will consider any other comments on this consolidation of these sections in this draft in preparing the final BTP.

l. Averaging of Similar Materials:

One commenter on Section 4 ("Initial Waste Classification") of the Sandia draft, stated that, "For similar materials (i.e., resin and resin, soil and soil), originating from different sources, classification can be based on the volume or mass weighted concentrations from each source averaged over the final volume or mass."

Staff Response:

The NRC agrees that the classification of a mixture of similar homogeneous waste types can be based on the total activity and total volume (or mass, as appropriate) of the waste. The 1995 BTP Factor of 10 Rule for mixing similar homogeneous waste types has been removed and replaced with a test for the homogeneity of blended similar homogeneous waste types.

m. Averaging of Dissimilar Materials:

One commenter on Section 4 of the Sandia draft stated that for dissimilar materials (i.e., resin and soil, resin and filters) classification can be determined by the highest individual waste type contributor (refer to Section 6.1)

Staff Response:

[This response has been superseded by the May 2012 draft].

The comment refers to a statement made in Section 4 of the Sandia draft BTP, which states that "If the disposal container holds a mixture of *dissimilar waste types*, and the highest waste classification of any individual item of the mixture is not higher than the waste classification of the total mixture (average of the total activity over the total volume or mass), then the classification can be based on the average concentration." This statement in the publically available draft is consistent with the Section 3.8 of the 1995 BTP [now Section 4.7], which states that, *dissimilar waste types* can be mixed and then classified using the average of the total activity over the total volume or mass of the waste in the container, so long as "the classification of the mixture is not lower than the highest waste classification of any individual components of the mixture."

n. Classification of Discrete Items:

One commenter stated that references to "discrete items" and classification in accordance with Section 7 should be removed from Section 4 [of the Sandia draft]. [Section 4 addresses initial characterization of waste and Section 7 addresses classification of individual discrete items].

Staff Response:

The statement in Section 4, of the Sandia draft BTP is correct as written and is meant to guide the reader to the Section where individual items are addressed.

o. Section 6 of Sandia Draft, "Classifying a Heterogeneous Mixture of Similar Waste Types":

One commenter asked that Section 6 of the Sandia draft be revised to read "Classifying a Heterogeneous Mixture of Dissimilar Waste Types" (not similar waste types).

Staff Response:

Section 6 of the draft released for public comment, has been renamed "Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters" and is written for classifying mixtures, where all the pieces in the mixture are of *same* waste type (activated or contaminated or cartridge filters).

p. Section 6 of Sandia Draft, "Classifying a Heterogeneous Mixture of Similar Waste Types":

Section 6.1 should be titled; "Conservative Classification Based on Highest Individual *Contributor*" (the term used in the Sandia draft in place of "contributor is "item").

Staff Response:

The NRC agrees with this comment, and text has been revised.

q. Section 6 of Sandia Draft, "Classifying a Heterogeneous Mixture of Similar Waste Types":

Paragraph 2 should be revised to delete references to 37 MBq (1 mCi) per item, which is applicable only to activated metals.

Staff Response:

The 1995 BTP, for activated metal and contaminated materials, allowed concentration averaging over the volume or mass of the mixture, if all contributors to the mixture have activities less than 37 MBq (1 mCi). The revised BTP now extends that policy to mixtures of cartridge filters.

r. Section 6 of Sandia Draft, "Classifying a Heterogeneous Mixture of Similar Waste Types":

The commenter recommended that paragraph 3 of the Sandia draft should be revised to address classification of individual contributions to the total package. The commenter stated that classification should be based on the highest waste class concentration of any individual contribution of each *dissimilar waste type* within the package. The commenter suggested that, if *dissimilar but homogeneous waste streams* (e.g., resin and soil) are mixed and the highest waste class is equal to the average waste class, then a licensee may classify the mixture based on the total activity divided by total volume or mass.

Staff Response:

Section 4 of the Sandia draft BTP states that "If the disposal container holds a mixture of dissimilar waste types, and the highest waste classification of any individual item of the mixture is not higher than the waste classification of the total mixture (average of the total activity over the total volume or mass), then the classification can be based on the average concentration." This statement in the Sandia draft is consistent with the Section 3.8 of the 1995 BTP which states that, dissimilar waste types can be mixed and then classified using the average of the total activity over the total volume or mass of the waste in the container, so long as "the classification of the mixture is not lower than the highest waste classification of any individual components of the mixture." The revised BTP is consistent with the above. The commenter did not provide any reasons for changing the previous (and current) position, and because staff agrees with the previous (and current) position, it has not made any changes.

The NRC disagrees with the commenter's recommendation that the classification of a mixture of items of *dissimilar but homogeneous waste streams* (e.g., resin and soil) should never be lower than the greatest classification of the inputs. This guidance instead recommends that such mixing should be evaluated on a case by case basis. Averaging based on the total activity and total volume of both wastes may be permissible in some cases. This position is the same as the 1995 BTP position. The commenter did not provide any reasons why the position should be changed and because the staff agrees with the position, it has not been changed.

s. Section 6 of Sandia Draft, "Classifying a Heterogeneous Mixture of Similar Waste Types":

One commenter referenced Sections 6.2 and 6.3 of the Sandia draft and stated that since gamma activity at 100 years post closure is reduced (Co-60 activity is essentially non-existent and Cs-137 activity is reduced by a factor of ten), the factor of 1.5 is only applicable to Nb-94 in activated hardware or cartridge filters generated during activated hardware cutting activities. Tables A and B were developed to control classification of irradiated hardware and should be captured in Section 7 (relocation of Section 3.3 of the original BTP into section 7 of the revision will accomplish this).

Staff Response:

As noted in the Technical Basis for the 1995 BTP, the Table A test is made to ensure that gamma-emitting sealed source-like items of activated metal *and contaminated materials* are removed from a mixture and managed separately. The 1995 BTP is not clear on the origin of the Table B test for non-primary gammas, but the purpose of the Table B test is to ensure that non gamma-emitting sealed source-like items of activated metal *and contaminated materials* are removed from a mixture and managed separately.

t. Section 8 of Sandia Draft, "Determining the Concentration and Volume of the Waste":

One commenter stated that the table in Section 8 is appropriate as presented with one minor modification, "solidified ion exchange resins" should be modified to read "solidified solid materials" may have their concentration averaged over the volume or mass of the solidified mass, and should retain the requirement that "if homogeneity is maintained in the solidified mass."

Staff Response:

The text has been changed to solidified masses, rather than just ion exchange resins.

u. References:

One commenter recommended that Section 12, References, include the U.S. NRC 1991 Waste Form Technical Position, Rev. 1, dated January 24, 1991.

Staff Response:

The staff has added that document to the list of references.

v. Economic viability of disposal facilities

To ensure the economic viability of commercial sites, the quantity of Classes of LLRW must be established and/or maintained within a definable range. For example, if the Andrews County disposal site received less Class A, B and C LLRW than it is designed for, they may need to increase the cost of disposal which will likely exclude the biomedical community and cause prolonged interim storage and many medical and research facilities to shut down their services. Consequently, the economic viability of these disposal sites is critically necessary to ensure the overall optimization of the safety and security of licensed radioactive materials in thousands of sites in urban and suburban communities throughout the U.S.

Response:

This issue was analyzed in Section 3.1.3, "Impact on Existing LLRW Management Program," in the staff's paper for the Commission on LLRW blending, SECY-10-0043. In that section, the staff stated, "The staff did not independently analyze the economics of the facility [in Andrews County, Texas] and the potential effect of smaller Class B/C waste stream volumes, since NRC's responsibilities as a regulatory agency are limited to ensuring the protection of public health and safety and the environment and promoting common defense and security."

w. Activity limit for Cs-137 sealed source

The difference in concentration values in 10 CFR Part 61 and the CA BTP for Cs-137 is due to the difference between homogeneous and heterogeneous waste. However, perhaps NRC should review why the difference is a factor of 30 and not 10 [the Cs-137 small item activity limit is approximately 1/30th the activity of the Class C limit for Cs-137 in a 0.2 m^3 (55 gallon) drum].

Response:

The staff agrees and the staff has reviewed the scenario that is the basis for the factor of

30 difference. The new exposure scenario that establishes the Cs-137 activity limit (4.8 TBq (130 Ci) for Class C waste) results in a limit that is about 1/8th of the allowable limit. The staff has used reasonably foreseeable, but conservative scenarios to establish limits for items such as sealed sources that may remain discrete and not become soil-like, as was assumed in the technical basis for 10 CFR Part 61.

Appendix D: Analysis of Public Comments from October 20, 2011, Public Workshop

Background:

In addition to the public comments received in response to the January 2011 *Federal Register* Notice and February 2011 public workshop, the staff held another workshop in Albuquerque, NM, on October 20, 2011, to receive comments on a revised draft made available to the public in September 2011. Those comments are addressed in theis Appendix. Several stakeholders also provided written comments after the October workshop. Two were from industry and are listed in the table below. In addition to industry comments, the four States with disposal facilities and the LLRW Forum provided formal comments, and these are addressed in Appendix E. While the staff has addressed each of the comments from the October workshop in this Appendix, the staff has not documented responses to all of the written comments submitted after the October 20, 2011, workshop. All of the written comments were considered in revising the BTP, however.

Stakeholder Input:

The following are the documents related to public comments on the draft revision (Rev. 1) to the BTP completed in August 2011 and made publicly available in September 2011.

Document Type	Author	Date	Organization	ADAMS ML #
Draft Rev. 1 of BTP	NRC staff	August 2011	NRC	ML112061191
Meeting Transcript, October 20, 2011, Public Workshop on BTP	N/A	October 20, 2011	NRC and the public	ML113000164
Letter	F. Marcinowski	November 18, 2011	U.S. Dept. of Energy	ML12131A617
Letter	Lisa Edwards	February 16, 2012	Electric Power Research Institute	ML120520558
Letter	Thomas E. Magette	February 21, 2012	EnergySolutions	ML120890046
Letter	Lisa Edwards	April 2, 2012	Electric Power Research Institute	ML121220126

Analysis of Comments:

1. Homogeneous wastes, including blending:

   a. Section 3.2.1 of the BTP [now Section 4.2.1], "Homogeneous Waste Types," identifies wastes that can be treated as homogeneous for the purpose of waste classification. Such wastes are not subject to averaging constraints. The BTP also states that if available information (e.g., process knowledge, surveys to characterize waste for transportation) indicates there is a hot spot, appropriate action, such as the removal of an item, should be taken. The BTP should be clearer on the use of this available information.

      Staff Response:

      In response to this comment, the NRC staff reviewed the basis for the designation of some waste types as homogeneous and the requirements of the performance objectives of 10 CFR 61. As explained in greater detail in Section 4.2.1, each waste stream designated as a homogeneous waste type is so designated because the staff, based on multiple years of experience, expects these waste streams to be uniform in the context of inadvertent intrusion. Upon reconsideration, the staff also concluded that this basis constitutes "reasonable assurance," as required by § 61.40, of intruder protection from hot spots in these waste streams. Furthermore, additional investigation of hot spots in these waste streams is likely to be contrary to efforts to maintain worker doses ALARA. Therefore, the guidance to take additional actions in response to hot spots detected in waste designated as a homogeneous waste type has been removed from the guidance.

      From a larger perspective, the staff notes that the designation as a homogeneous waste type is based on NRC and industry experience. Experience may develop to show that additional waste types may routinely be regarded as homogeneous (e.g., see Comment 1.b). Similarly, although the staff expects it is unlikely, it is possible that industry-wide process changes could occur that would indicate that a particular waste type should no longer be regarded as homogeneous. For example, development of a new waste solidification procedure that tends to create hot spots in waste could call into question the routine designation of solidified waste as homogeneous. In short, a designation based on experience with the waste could change with additional NRC and industry experience.

   b. Section 3.2.2 [now Section 4.2.2] of the BTP, "Intentional Blending During Waste Processing," addresses the homogeneity of "large-scale blending," i.e. intentional blending during waste processing that could cause an increased risk for an inadvertent intruder. The BTP notes that wastes from such blending would have a sum of the fractions closer to the classification limit than incidentally blended waste and the intentional blending is expected to produce more of these wastes. However, processors routinely blend wastes, including blending that produces a final waste that is near the class limits. These types of wastes should not be singled out for special homogeneity testing.

      Staff Response:

In response to this comment the NRC staff reviewed its basis for recommending homogeneity testing for waste intentionally blended to reduce its classification. The NRC staff agrees that the hypothesized sum of fractions of blended waste is an incomplete justification for recommending additional homogeneity testing for this waste stream. As described in Section 4.2.1, certain waste streams are designated as homogeneous waste types and assumed to be homogeneous based on multiple years of experience with these wastes. The NRC staff lacks similar experience with intentional blending of waste to lower its concentration to lower waste classification. The BTP text has been updated to reflect this reconsideration.

The NRC staff agrees, however, that blended wastes should not be "singled out," as the commenter suggests. In response to this and other comments, the NRC staff developed a threshold for when NRC staff recommends that homogeneity should be demonstrated. This threshold applies to any waste not specifically designated as a homogeneous waste type (see response to comment no. 1.e and Section 4.2.2). Based on information presented by industry (Tran, 2008), the NRC staff expects that a processor blending waste to reduce its concentration to a lower waste classification may produce waste that meets the recommended threshold for demonstrating homogeneity (Table 1). Thus the NRC staff expects that the homogeneity guidance presented in Section 4.2.2 will be applicable to waste blended to reduce its classification. The guidance in this section has been revised to emphasize the use of process knowledge and reasoned explanations instead of direct measurements to demonstrate homogeneity when possible, in an effort to minimize worker dose. Furthermore, as previously discussed, the designation of certain waste streams as homogeneous waste types (Section 4.2.1) is based on NRC and industry experience. As experience is gained with particular blending processes, this experience may be relied on in subsequent demonstrations of waste homogeneity.

c. Appendix B of the BTP describes a well-drilling scenario that is the basis for the test for homogeneity of blended waste types. The scenario presented is not reasonably foreseeable for residential wells. Instead of drill cuttings being spread on the surface, these cuttings are typically collected in a pit and covered. The staff should use a more reasonable scenario for the homogeneity test.

Staff Response:

In a risk-informed system, it is useful to examine both high-probability, low-consequence events and low-probability, high-consequence events. In the context of inadvertent intrusion into a LLRW site, the NRC staff routinely examines recreational scenarios (typically high-probability, low consequence events), dwelling construction and subsequent occupation of the site (lower-probability, higher-consequence events), and drilling scenarios (also lower-probability, higher-consequence events). In the context of developing guidance that explicitly addresses hot spots in the waste, the most limiting scenarios are drilling scenarios. Drilling scenarios are more limiting than dwelling construction when considering hot spots because dwelling construction mixes a relatively large amount of waste with soil, averaging away hot spots.

The NRC staff agrees that drilling methods that collect drill cuttings in a disposal pit (e.g., mud rotary drilling) appear to be more common for drilling residential water wells than methods in which cuttings are spread on the land surface (referred to here as an “exposed-cuttings” scenario). The NRC staff agrees that it is useful to evaluate the potential effects of mud rotary drilling at a LLRW site. In response to this comment, the NRC staff evaluated a scenario in which drill cuttings are disposed of in a mud pit on site and covered with clean soil. Because the cuttings are initially covered, the hazard from short-lived gamma emitters (e.g., Cs-137), which are important to dose in a scenario in which cuttings are spread on the surface, is essentially eliminated. Instead, the primary exposure pathways are from radionuclides leaching into groundwater[16] and exposure to long-lived gamma emitters (e.g., Nb-94) after sufficient erosion has taken place at the site to expose the cuttings in the disposal pit.

In the staff’s previous analysis of an exposed-cuttings scenario, very similar results were obtained by evaluating intrusion into Class A waste at 100 years or intrusion into Class C waste at 500 years. Because the dose in the mud rotary drilling case is primarily due to long-lived radionuclides (i.e., C-14, Tc-99, and Nb-94), there is very little difference in source term between intrusion at 100 and 500 years. Because the Class C limits for these radionuclides are a factor of 10 greater than their Class A limits, the predicted dose from intrusion into Class C waste at 500 years is essentially a factor of 10 greater than the dose from intrusion into Class A waste at 100 years. Furthermore, postulating longer-lived intrusion barriers has little effect on the predicted dose. That is, assuming that intrusion does not occur until 800 or 900 years has little effect on the potential dose from Tc-99, C-14, or Nb-94 in the mud rotary drilling scenario. Thus, while no safety concerns were identified for intrusion into Class A waste in the mud rotary drilling scenario, the staff found that a hot spot in Class C waste could present more of a concern.

Although the mud rotary drilling scenario could present potential hazards to an inadvertent intruder, the hazard is primarily due to radionuclides that are not expected to be classification-controlling in commercial LLRW (i.e., Tc-99, C-14, Nb-94). In the August 2011 draft BTP, the staff previously concluded that it was appropriate to base the guidance on Cs-137, even though Np-237 and Nb-94 were predicted to cause a greater potential dose. The staff made this conclusion because neither Np-237 nor Nb-94 is expected to be present in significant quantities in commercial LLRW and because Nb-94 is expected to be present in activated metal, which is not consistent with the postulated agricultural scenario. However, in the staff’s previous analysis, the potential dose presented by these radionuclides was within a factor of 4 of the dose from Cs-137, which was used as the basis for the homogeneity guidance. Thus in the previous analysis, the NRC staff concluded that guidance based on Cs-137 would not lead to excessive doses in the unlikely case that Np-237 or Nb-94 were present in significant quantities in the waste. In the mud

[16] Because initial exposure to short-lived gamma emitting radionuclides served as a basis for the homogeneity guidance in the staff’s initial analysis (i.e., in which cuttings are spread on the surface), that analysis was limited in that it did not include risks from radionuclides leaching into groundwater.

rotary drilling case, the potential hazard from these radionuclides suggests some effort to reduce hot spots in the waste containing these radionuclides is warranted. However, the improbability of any of these radionuclides controlling classification in commercial LLRW suggests it would not be consistent with ALARA principles for waste generators or processors to conduct direct measurements to evaluate the homogeneity of waste based on a postulated mud rotary drilling intrusion scenario. Measurements may be justified in the unlikely case that Tc-99, C-14, or Nb-94 are known to be present in significant quantities.

While the NRC staff finds the mud rotary drilling scenario to be informative, it disagrees with the commenter's position that other drilling methods should not be considered. Drilling methods in which cuttings are spread on the land surface (e.g., cable tool drilling, auger drilling), though not as common as mud rotary drilling, are sometimes used for water well drilling. These drilling methods also have other applications, such as drilling boreholes for site exploration. In addition, a scenario in which an intruder drills a well and spreads drill cuttings on the site serves as a surrogate for other potential intrusion scenarios in which a small amount of waste is exposed on the land surface. Drilling scenarios in which cuttings are spread on the land surface are commonly used in both NRC and DOE LLRW analyses (NRCP, 2005; Koffman et al., 2005).

Although the NRC staff disagrees with the commenter's suggestion not to use an exposed-cuttings scenario as a basis for the homogeneity guidance, in response to this comment, the NRC staff did revisit some of its previous assumptions. To address comments about the difficulty of detecting a 0.03 m^3 (1 ft^3) hot spot in mixable waste, the NRC staff re-evaluated the potential impacts of various sizes of hot spots. In this analysis, the staff subjectively chose to represent a hot spot as roughly spherical. The NRC staff understands that hot spots are unlikely to be spherical, but considered a sphere as an approximation and a moderate assumption. Although more conservative assumptions could be made (e.g., a vertically-oriented hot spot that coincides with the intruder's drill bore) the NRC staff judged these geometries to be too improbable to form the basis for the guidance (i.e., not reasonably foreseeable). Specifically, the staff considered that an intruder would exhume only a fraction of any hot spot with a diameter greater than the well bore. For example, based on the assumed spherical hot spot geometry and the assumption that an intruder uses a 0.02 m (8 in.) diameter drill bore, an intruder encountering a 0.34 m^3 (12 ft^3) hot spot would exhume approximately the same volume of waste considered in the staff's original analysis (i.e., 0.03 m^3 [1 ft^3]).

The staff also considered a smaller but higher-concentration hot spot. For example, an intruder using a 0.2 m (8 in.) well bore would exhume a little more than 60% of a roughly spherical 0.015 m^3 (0.5 ft^3) hot spot. In a package with an internal volume of approximately 5 m^3 (180 ft^3), this hot spot could have a sum of fractions of approximately 340 and the package would still meet the class limit. Based on the staff's analysis of an exposed-cuttings scenario, this hot spot could lead to a dose of approximately 30 mSv/yr (3 rem/yr) to an inadvertent intruder. This dose is in a range the IAEA indicates should motivate consideration of different disposal options (IAEA, 2011).

However, if a licensee ensures waste is blended well enough that 0.15 m^3 (5 ft^3) sections of waste do not have a sum of fractions exceeding 10, the same size hot spot (i.e., 0.015 m^3 (0.5 ft^3)) would be limited to a sum of fractions of approximately 100. Depending on the classification-controlling radionuclide, this hot spot could lead to a dose of approximately 9 mSv/yr (900 mrem/yr), and no size hot spot in the package would lead to a dose greater than 14 mSv/yr (1.4 rem/yr). If additional allowance is made for the consideration of other radionuclides in the drill column (i.e., in waste outside of this hot spot), these doses are still expected to remain below 20 mSv/yr (2 rem/yr). Doses in this range (i.e, between 1 mSv/yr (100 mrem/yr) and 20 mSv/yr (2 rem/yr) are in a range the IAEA indicates can be managed by reducing the probability of exposure (IAEA, 2011). In light of this IAEA guidance, the NRC staff considered that, even if it is assumed that an intruder drills through a container that contains a hot spot, the chance of encountering the hot spot decreases with its size. That is, even if intrusion into a waste package containing a hot spot is evaluated as a consequence (i.e., assigned a probability of 1), hitting a small hot spot (which tend to present higher risk because they can have a higher sum of fractions) further reduces the likelihood of the scenario. Thus, the NRC staff judged that, the predicted 14 mSv/yr (1.4 rem/yr) dose from hitting a small (e.g., less than 0.015 m^3 [0.5 ft^3]) hot spot is not excessive. Based on these considerations, the staff revised the homogeneity guidance to indicate licensees should consider 0.15 m^3 (5 ft^3) volumes of waste rather than 0.03 m^3 (1 ft^3) volumes of waste (Section 4.2.2).

d. Section 3.2.2 [now 4.2.2] of the BTP states: "If the demonstration of homogeneity is based on the characteristics of the input waste streams, processors should verify radionuclide concentrations provided by the generator." The guidance for verification of radionuclide concentrations for blended wastes should not be different from other types of waste.

Staff Response:

The NRC staff agrees that the guidance for verification of influent radionuclide concentrations for blended waste should not be different from the guidance for verification of influent radionuclide concentrations used by other processors. Therefore, this guidance has been removed from Section 4.2.2 [was Section 3.2.2] of this document. However, other commenters have raised more general concerns about verifying generators' reported radionuclide concentrations (see Appendix E, State of Utah Comment 7.a). In response to these comments, the NRC staff is evaluating the issue of verification of waste characterization for all generators and processors.

e. Two commenters requested that the NRC staff provide more information about when homogeneity testing is recommended. One noted the BTP contains guidance for large-scale blending, but does not specify when the amount of blending is so significant that special guidance is needed. The commenter suggested the BTP should distinguish between routine blending that occurs now and larger scale blending that may need special guidance. Another commenter noted that very small quantities of LLRW from material licensees are blended by commercial processors to form Class A waste for disposal. The commenter also noted that, because of the small quantities involved, the commenter expected the practice to be considered small scale blending.

Staff Response:

The NRC staff agrees that there should be a quantitative metric for determining when homogeneity testing is recommended. To develop this metric, the staff considered the factors that contribute to the potential hazard from hot spots in mixable waste. Specifically, if none of the contributors to a mixture is very concentrated (relative to the class limit), the potential hazard is small. Similarly, if the amount of waste generated is small (relative to the amount of waste disposed of at a site), the probability an intruder will encounter a hot spot is small. Thus a threshold for homogeneity testing based on intruder protection depends on both the radionuclide concentrations in the influent waste streams (which affects the potential hazard from incompletely mixed waste) and the quantity of waste produced (which affects the chance an intruder will encounter the waste).

A risk-based threshold for homogeneity testing could focus on volumes and concentrations of waste that would increase the risk to an intruder beyond a risk-based dose limit. However, because neither industry nor the NRC staff has sufficient experience of all the processes that could produce hot spots in mixable waste (e.g., blending of waste to reduce its classification), it is difficult to predict hot spot frequency. The frequency of hot spots is necessary to link the probability an intruder will hit a hot spot with the quantity of waste disposed of at a site. Furthermore, 10 CFR 61 does not include a risk-based limit for intruder doses. Instead, the DEIS and FEIS for 10 CFR 61 use a consequence-based limit of 5 mSv/yr (500 mrem/yr) as a basis for intruder protection (see response to comment 6.a). Without the necessary information about hot spot frequency or a risk-based dose limit for intruder protection, the NRC staff subjectively chose concentrations and volumes to establish a threshold for homogeneity testing (Table 1) based on the reasoning described in Section 4.2.

f. Section 3.2.2 [now 4.2.2] of the BTP specifies criteria for the homogeneity of waste from intentional blending. Waste would be evaluated against these criteria prior to being shipped for disposal. In practice, the radioactivity distribution of wastes may change due to vibration during handling and transport, during ion exchange (for resin wastes) that continues to occur after disposal, density differences, and other factors. NRC should consider that the waste homogeneity at the time of intrusion is different from that when it is shipped for disposal.

Staff Response:

The draft BTP proposes a test to be applied when waste is shipped for disposal because that is when waste is classified, and the BTP is related primarily to waste classification. However, the NRC staff agrees that the BTP ideally applies to waste after disposal. In fact, the BTP ideally would apply to waste at the earliest reasonably foreseeable opportunity for inadvertent intrusion (e.g., typically assumed to be the end of the institutional control period for Class A waste and the end of reliance on engineered intrusion barriers for Class C waste).

The NRC staff is not currently aware of studies that demonstrate that hot spots in mixable waste are reliably removed during transportation or during waste disposal. However, such studies potentially could form the basis for an alternate approach to demonstrating waste homogeneity. The NRC staff expects the necessary demonstration would rely on studies of radionuclide distribution in physically, chemically, and radiologically similar wastes. For example, a study that demonstrates hot spots in blended ion exchange resins are reliably eliminated during transportation to a disposal site could serve as a basis for a reasoned conclusion that similar blended waste (e.g., waste composed of the same types of ion exchange resins with a similar range of radionuclide concentrations) is homogeneous in the context of waste classification.

While this approach may be appropriately applied to resin waste, as the commenter suggests, the utility of this approach for resin waste is unclear. Specifically, because many resin wastes are shipped as LSA-II material under 10 CFR § 71.4(2), licensees are required to demonstrate that radionuclides are "distributed throughout" the waste. As discussed in more detail in Section 4.2.2, this transportation requirement is more restrictive than the disposal-based homogeneity criterion in this guidance because it is based on the average activity in the waste rather than the class limit, and it is based on a smaller volume of waste (i.e., 0.1 m^3 [3.5 ft^3] rather than 0.15 m^3 [5 ft^3]). Thus, demonstrating compliance with this transportation requirement is sufficient (but not necessary) to demonstrate waste homogeneity for disposal.

g. The BTP's proposed test for homogeneity, based on preliminary EPRI (Electric Power Research Institute) investigations, will require significantly more surveys to demonstrate compliance. The staff should re-evaluate this test to determine if another approach can be utilized to ensure that blended waste has sufficient homogeneity.

Staff Response:

In the August 2011 draft BTP, surveys were referenced with respect to two different aspects of the homogeneity guidance: testing for homogeneity and evaluating the uncertainty in classification calculations. In response to this comment, the NRC staff found that, for wastes near a class limit, a greater number of survey measurements would be needed to follow the guidance related to uncertainty in waste classification calculations than for the recommended homogeneity testing. The NRC staff agrees that the proposed recommendation for reducing the uncertainty in waste classification calculations in the August 2011 draft BTP could be difficult to implement and contrary to "as low as is reasonably achievable" (ALARA) principles. The NRC staff has significantly revised this section of the draft BTP (Section 4.2.3) and removed the specific recommendations for quantifying uncertainty in waste classification calculations. The NRC staff assumes that licensees will use existing quality assurance programs for waste classification (see Section 4.7).

The staff also has taken several steps to minimize the measurements made to demonstrate waste homogeneity. First, the staff has developed a threshold for homogeneity testing (Table 1) to indicate minimum concentration differences and annual volumes of waste produced below which no homogeneity testing is recommended. Second, the staff has revised the proposed homogeneity test so that it is based on a larger volume of waste (i.e., 0.15 m^3 [5 ft^3] as compared to 0.03 m^3 [1 ft^3]), which is expected to require fewer measurements to detect. Third, the staff developed alternate approaches based on site-specific or waste-specific information that could reduce or eliminate the need for homogeneity testing. Finally, the staff has revised the BTP text to emphasize the use of process knowledge and reasoned conclusions instead of direct measurements whenever possible to demonstrate waste homogeneity. The staff encourages licensees to use these alternative approaches or methods when possible to minimize worker dose, in accordance with ALARA considerations.

h. If a Class A mixture of waste that has already been disposed of does not meet the homogeneity test prescribed in the BTP, it may still be acceptable for disposal based on a site-specific analysis.

   Staff Response:

   The staff assumes that the commenter is referring to the homogeneity test prescribed in the August 2011 draft of the BTP. The staff agrees that waste that does not meet a test in the BTP may still be acceptable for disposal based on a site-specific analysis. The generic guidance in the BTP is suitable for all LLRW disposal facilities, and does not take into account site-specific intruder scenarios or design features that may affect protection of public health and safety. Thus, a site-specific analysis of waste that does not meet the homogeneity guidance in the BTP could potentially demonstrate that the waste is safe for disposal.

i. For an intruder scenario involving well drilling, likelihood of intrusion could be considered by dividing the area of the well bore over the area of the disposal site.

   Staff Response:

   The proposed formula avoids the difficulty of determining the probability of intrusion by assuming that intrusion occurs on the site (probability of one). However, the NRC staff disagrees with the suggested formula because it implies there is one area of elevated concentration (i.e., hot spot) on the site. The NRC staff instead suggests that likelihood of intrusion would be based on dividing the sum of the areas of hot spots by the area of the disposal site. Because waste practices change (as evidenced by the recent industry proposal to blend waste), it would be difficult, although potentially possible, to determine an appropriate distribution for the number of hot spots expected on a site. The NRC staff agrees that a formula of this type could be used to estimate the probability of an inadvertent intruder encountering a hot spot.

   The larger difficulty would then be in the application of the probability calculated with that formula. If 10 CFR 61 included a risk-based dose limit for intruder protection, a licensee would multiply the potential hazard (i.e., dose) by the probability of the hazard occurring to determine the risk. However, the 5 mSv/yr (500 mrem/yr) dose limit currently used to determine compliance with 10 CFR § 61.42 is a consequence-based limit, rather than a risk-based limit. The value of 5 mSv/yr (500 mrem/yr), rather than a lower value, is based in part on the acknowledgement that inadvertent intrusion is a hypothetical event (NRC, 1994). Thus, it appears to be inappropriate to compare the risk of inadvertent intrusion to a consequence-based limit, especially when that consequence-based limit already is based in part on the low probability of intrusion. Development of a risk-based limit for inadvertent intrusion is beyond the scope of the BTP and would need to be addressed in the context to a revision of 10 CFR Part 61.

2. Classification of individual wastes, including factors of 1.5 and 10:

   a. The 1995 version of the BTP states in Table A that small items larger than the activity levels specified in the table should *potentially* be removed from a mixture. Another test that needs to be applied to determine if removal is needed is the Factor of 1.5 test. The revised draft BTP states that small items with activities larger than the Table A values should be removed and treated as individual items, and no other possibilities are provided or acknowledged. The original position in the 1995 BTP should be retained.

      Staff Response:

      The staff believes that the current position as stated above (i.e., that small high-activity items should be managed individually) is appropriate. The 1995 BTP also states, without qualification and in several places (Section 3.3.2 and in Figure 1), that small, high activity pieces should be managed individually. Although the word "potentially" used in the title of Table A in the 1995 BTP for small piece individual treatment, no guidance is given for the conditions under which an alternative would be used or justified, and no flexibility is provided in the other BTP statements about small items. In addition, small, high activity items that are still intact at the time of intrusion pose a hazard that needs to be addressed.

3. Cartridge Filters:

   a. The revised BTP recommends the same averaging constraints on irradiated reactor hardware and cartridge filters. Cartridge filters do not pose the same hazard as irradiated hardware and should be treated differently in the BTP, i.e., they should be treated as homogeneous wastes. Filters have lower radioactivity levels (especially for Cs-137 and Nb-94) and will be unlikely to retain radioactivity within a discrete volume. For the scenario in the BTP that is the basis for the averaging constraints on filters, it is assumed that a filter would be excavated and transported. Such movement would cause radioactivity in the filter to spill out. The staff should re-examine the assumptions for the exposure scenario for cartridge filters and determine what changes may be needed in the BTP.

      Staff Response:

      The NRC agrees that cartridge filters do not always pose the same hazard as irradiated hardware, and has considered several approaches for addressing cartridge filters that accounts for their difference from typical individual items, such as activated metals or sealed sources. The first is for the BTP to simply state that all cartridge filters may be treated as homogeneous waste, as is done for several waste types now, such as ion exchange resins. The second approach would be to allow for classification of cartridge filters as homogeneous wastes based on the physical and radiological properties of the filters. The primary radiological criterion is that the activity of each filter should be within activity limits based on calculated radiation doses to an inadvertent intruder, such as the Table A values in Section 4.3.2. The physical characteristics would be those that make cartridge filters different from discrete items containing radioactivity that could be carried away by an inadvertent intruder, such as perforations in the housing, and loose particles of radioactivity. Both of these characteristics could enable radioactivity to be dispersed upon handling, rather remain concentrated and potentially hazardous to an intruder. The staff has developed criteria which are contained in Section 4.3.4 that a licensee can use to evaluate cartridge filters of a particular design in a reactor system to justify their treatment as a homogeneous waste, considering their radiological and physical properties. The justification needs to be documented and made available to inspectors If filters are considered homogeneous they could be classified on a batch basis (rather than an individual basis) using the actual waste volume and the actual waste weight with a dose rate to curie method, thus saving worker dose. A third approach would be to use historical data to characterize filters, similar to the second approach, but all of the current averaging constraints for individual items would be applicable. As with the second approach, the analysis would be documented and subject to inspection by the regulatory agency. These wastes would be “managed” as homogeneous in the sense that not every cartridge filter would need to be characterized.

The staff has selected the second approach, because it is consistent with risk-informed, performance-based regulation. With respect to the first approach, the staff is aware that cartridge filters have had high concentrations of radioactivity in some cases (greater than Class C) and that a staff determination that all cartridge filters in all cases are homogeneous is difficult to justify. The staff is also believes that industry practices could change if such a position were taken, so that the average activities of filters could go up if constraints were eliminated. The third approach would presumably reduce worker exposures through less characterization of filters, but would retain the averaging constraints for individual items, which are not necessary if the long-lived gamma activity is low, and the physical characteristics of filters are different from activated metals and sealed sources. The staff therefore believes that the second approach is preferred, and has selected the BTP’s Table A values in Section 4.3.2 of the BTP as the radiological criteria for cartridge filters to be considered as homogeneous waste, for simplicity. Because this table is based on a small item carry away scenario, larger activity levels could be justified for cartridge filters. The staff will consider a specific scenario for cartridge filters as a basis for larger activity levels than Table A, if stakeholders believe that would be desirable.

b. Section 3.3., “Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters,” (Section 4.3 in the May 2012 draft) is a new section that consolidates three sections from the 1995 BTP for each of these waste types. The staff should consider addressing cartridge filters and contaminated materials in a separate section. These materials are mixed in practice, and cartridge filters may be encapsulated, and this new section could address that practice as well.

Staff Response:

The staff has addressed cartridge filters in a new, separate section because of the unique considerations concerning its management and the possibility that they can be classified as homogeneous waste in some circumstances. With respect to contaminated materials, they remain in the section with activated metals because they are subject to essentially the same averaging constraints as activated metals.

4. Definitions:

   a. The BTP should define risk-informed, performance-based, how it's used and what it actually means. When the NRC adopted a risk-informed performance-based approach they did not use the term, “risk-based,” but instead, “risk-informed,” where probability estimates were just one of the number of factors to help make decisions.

   Staff Response:

   NRC’s Strategic Plan (NUREG-1614) defines these the terms “risk-informed” and “performance-based” as follows:

   Risk-informed:

   - Decision making approach that uses risk insights, engineering judgment, safety limits, and other factors.
   - For establishing requirements that focus on issues commensurate with their importance to public health and safety.

   Performance-based:

   - Performance and results as the primary bases for decisionmaking
   - Performance-based regulations have these attributes, among others:
     - Measurable, calculable or objectively observable parameters exist or can be developed to monitor performance;
     - Objective, criteria exist or can be developed to assess performance; and;
     - Licensees have flexibility to determine how to meet the established performance criteria in ways that will encourage and reward improved outcomes.

   With respect to the use of the term, “risk-informed,” in revising the BTP, the staff has considered the conditional risk to an inadvertent intruder into the LLRW disposal facility in developing the concentration averaging provisions (conditional risk is risk assuming that the hypothesized intrusion occurs). In the context of the BTP, risk is the product of the radiation dose to an intruder 5 mSv/yr (500 mrem/yr) maximum, consistent with the technical basis for 10 CFR Part 61) and the probability of intrusion. Because the probability of future human intrusion activities cannot be quantified, the staff has subjectively considered the likelihood of such events in postulating scenarios that are the basis for the positions in the BTP. Human intrusion events which are reasonably foreseeable yet conservative, were postulated by the staff for developing the positions in the BTP. The staff recognizes that this use of the term may be different from other NRC programs where probabilistic risk assessments are used in risk-informed decisionmaking. The staff acknowledges that the approach for the BTP may be similar to the use of design basis accidents in the reactor program.

With respect to the term, “performance-based,” the revisions to the BTP are much more focused on licensees achieving the outcomes of concentration averaging, i.e., the protection of an inadvertent intruder, rather than forcing compliance with one method in the BTP for achieving that outcome. The revised BTP, consistent with performance-based regulation, allows for other approaches to achieve the desired outcome.

b. The revised BTP states that in evaluating a mixture of items in a package, one has to do it not just for the class driver nuclides, the previous position, but for all of the nuclides. Based on a preliminary investigation in looking at that revision, it has been determined that it is a significant extra burden to do that comparison for all of the nuclides instead of just the class drivers. The BTP should clarify that only class-driving radionuclides need to be evaluated.

Staff Response:

Staff has attempted to clarify this point so that only radionuclides control the classification and therefore the risk to an intruder are addressed. The revised definition for “classification controlling radionuclides in the BTP is as follows: “One or more nuclides, listed in Table 1 or Table 2 of 10 CFR § 61.55, that is the specific basis for the classification of a waste package. This could be a single nuclide, or multiple nuclides that make up 50% of the sum of fractions.”

The staff is seeking stakeholder input on this revised definition.

5. Use of Site-Specific Intruder Analysis in Lieu of BTP:

Although the BTP is based upon NRC’s generic waste classification system, to the extent possible, it should recognize that site-specific approaches for disposal including operational practices, waste forms, and waste containers, are key to assessing the suitability at a specific facility.

Staff Response:

The staff agrees that site-specific approaches for disposal may be useful. Additional text has been added to the Alternative Approaches section that identifies considerations for developing and approving site-specific averaging approaches within the existing classification system.

6. Scenario Selection for Inadvertent Intruder, including probability of intrusion:

a. The staff, in developing “reasonably foreseeable” scenarios for intrusion, should consider the compounding of conservative assumptions, so that the end result is no longer reasonably foreseeable. For example, the probability of intrusion is assumed to be 1, intrusion occurs immediately after the end of the active institutional control period of 100 years and a hot spot is assumed to be intruded into. The staff should consider these compounded conservative assumptions in developing scenarios.

Staff Response:

The staff understands that a compounding of conservatisms could produce, in aggregate, a scenario that is no longer reasonably foreseeable. The need to avoid this outcome was addressed in both the DEIS for 10 CFR Part 61 and in the staff's recent revisions to the BTP, as discussed below. The staff is open to specific suggestions that could provide additional assurance that only reasonably foreseeable scenarios have been analyzed.

With respect to 10 CFR Part 61, the NRC reviewed two alternatives for selecting the scenarios in the DEIS:

1. Based on judgment, devise a number of exposure scenarios, from the likeliest to the unlikeliest, assign a probability to each, and perform a risk analysis of the impacts; or
2. Based on judgment, determine a limited number of high consequence exposure scenarios, assume a probability of one, and perform a consequence analysis of the impacts of each.

For the first alternative (define scenarios and associated probabilities), among other things, the DEIS noted that ". . . <u>it would be extremely difficult if not impossible to determine and assign numerical probabilities</u>. Inadvertent intrusion is a hypothetical event that may or may not occur in the future." (Emphasis added) (NRC, 1981, DEIS, NUREG-0782 Vol. 2 p. 4-6)

Given these considerations, NRC staff stated in the DEIS that alternative #2 is the better approach, but noted that it also has drawbacks. One was that if extremely conservative scenarios were used, then the calculated results could be based on conservatisms multiplied by conservatisms. To address this concern, NRC adopted a limited number of intrusion scenarios based on consideration of typical human activities. In addition, once the intrusion occurs, reasonably conservative actions on the part of the intruders were assumed to occur. While intrusion is assumed to occur at 100 years for Class A waste, it does not occur until 500 years after closure for Class C.

Because it is not possible to make precise estimates of the probability of intrusion, the likelihood of intrusion is acknowledged implicitly in the 5 mSv/yr (500 mrem/yr) dose limit used for intruder protection. For example, NRC has previously indicated that it is appropriate to use an intruder dose limit of 5 mSv/yr (500 mrem/yr) instead of 1 mSv/yr (100 mrem/yr), the public dose limit in 10 CFR Part 20, because intrusion is a "hypothetical" event that may not occur (NRC, 1994). This higher limit essentially provides for a 20 percent probability of intrusion. Furthermore, the 5 mSv/yr (500 mrem/yr) limit is a factor of 20 greater than the 0.25 mSv/yr (25 mrem/yr) limit established in 10 CFR § 61.41 for protection of the general population from releases of radioactivity. This difference is largely attributable to the difference between the hypothetical nature of intrusion and the more likely possibility of exposure to small off-site releases, implying a 5 percent probability of intrusion. In addition, the inaccessibility of Class C waste to intruders was explicitly considered in establishing the Class C limits in 10 CFR§ 61.55, further reducing the implied probability of intrusion into Class C waste.

In addition to 10 CFR Part 61, the revised BTP has also positions that are designed to ensure that scenarios are reasonably foreseeable:

- It contains a new section that facilitates the use of alternative approaches to justify, e.g. a later time of intrusion (Class A waste disposed of with intruder barriers that meet the Part 61 requirement for Class C waste).
- The new position on testing for homogeneity is based in part on the likelihood of intrusion into a hotspot.
- The staff re-examined the scenario that is the basis for the limits on sealed sources, and used a more reasonable scenario, and as a result, increased the recommended limit for Cs-137 sources from 1.1 TBq (30 Curies) to 4.8 TBq (130 Curies).

As noted earlier, NRC has attempted to eliminate compounding of conservatisms, both in the development of 10 CFR Part 61 and in the BTP, and is open to suggestions on further improvements.

b. In considering the probability of intrusion, both the likelihood and the consequences of intrusion, rather than just the risk, should be presented to decisionmakers, in the interest of having complete information.

Staff Response:

Consideration of the likelihood and consequences of intrusion is addressed in the response to comment (a) above.

c. The BTP is unclear as to how probability of intrusion has been considered for the scenarios that are the bases for the positions. How has likelihood of intrusion been considered?

Staff Response:

As noted above in response to comment No. 6.a, in general, the staff has used an approach for selecting intrusion scenarios for the BTP positions that is similar to those used in the DEIS for 10 CFR Part 61. The difference is that the scenarios are designed to address hot spots, whereas the DEIS assumed a uniform concentration of wastes. Hot spots or heterogeneity in waste can be averaged in classifying waste. Without having some constraints on how concentrated hot spots may be or how large a volume would be acceptable, generators could perform unconstrained averaging of items. The Concentration Averaging BTP identifies these constraints. Consideration of the likelihood of intrusion is addressed in detail in the response to comment (a) above.

d. In lieu of selecting a single scenario for establishing constraints for averaging for different waste types, NRC should use expert elicitation to establish a probability spectrum for intrusion.

Staff Response:

While the staff believes that expert elicitation may be useful for addressing site-specific intruder analyses for averaging constraints on waste, we do not believe it is necessary for developing the generic guidance in this BTP. Expert elicitation is a formal, highly structured, and well-documented process whereby expert judgments, usually of multiple experts, are obtained.

These revisions to the 1995 BTP build on the approaches in the DEIS for 10 CFR Part 61 and the 1995 BTP which used expert judgment, not expert elicitation. In the revised BTP, the staff has somewhat modified the 1995 positions, including the blending position (which was directed by the Commission), the use of somewhat different scenarios for selecting limits on sealed sources, and other relatively incremental changes to the BTP.

With respect to the probability spectrum, the 10 CFR Part 61 DEIS considered the approach of devising a number of exposure scenarios, from the likeliest to the unlikeliest, assigning a probability to each, and performing a risk analysis of the impacts. It concluded that ". . . it would be extremely difficult if not impossible to determine and assign numerical probabilities. Inadvertent intrusion is a hypothetical event that may or may not occur in the future." (Emphasis added) (NRC, 1981, DEIS, NUREG-0782 Vol. 2 p. 4-6).

e. The averaging positions in the BTP are based upon intruder scenarios identified in Appendix B of the draft, such as the "carry-away" scenario for sealed sources. Section 3.9 [now Section 4.9], "Alternative Approaches for Averaging" acknowledges that other scenarios might be justified. The BTP should better recognize that other scenarios can be used and justified, and that probability of intrusion may be utilized. Examples would also be helpful.

   Staff Response:

   The revised draft of the BTP now incorporates a section on the use of site-specific intruder assessments, including the use of scenarios different from those in the Appendix B of the BTP. Licensees could develop other scenarios. Staff believes that the current provisions in the Alternative Approaches provide several options for those licensees seeking to dispose of higher activity gamma-emitting sealed sources. With respect to the use of probabilities, see the staff's response to comment 6.a above and Section 4.9.4 in the BTP.

f. In the DOE program, inadvertent intrusion events that contact waste may be assumed to be limited to drilling or simple excavation scenarios involving the use of relatively unsophisticated tools and commonplace machinery, and the doses calculated for an inadvertent intruder will depend on waste disposal facility design and operating practices, and may be reduced by practices such as disposal below depths normally associated with common construction activities, the use of intruder barriers or durable waste forms or containers, or distributed disposal of higher activity waste. Assumptions regarding these factors are determined on a site-specific basis.

   The inadvertent intruder assessment considers at a minimum the appropriateness of including an acute construction scenario, an acute well-drilling scenario, and a chronic agricultural scenario. However, all these scenarios may not need to be assessed for a particular disposal facility and actual scenarios were developed on a site-specific basis with the appropriate balance between conservatism and plausibility based on engineering judgment. DOE does not use a sealed source "carry away" scenario that NRC used in both the 1995 BTP and the revised draft, and this scenario is not consistent with those used in the DEIS for 10 CFR Part 61.

Staff Response:

The staff acknowledges DOE's approaches for protecting an inadvertent intruder and has used aspects of it in revising the BTP. Specifically, the BTP facilitates the use of site-specific intruder assessments, as used in the DOE program. The staff also acknowledges that DOE's program is different in some respects from the commercial program, and that some differences in intruder protection approaches are therefore justified. For example, DOE plans to oversee the sites in perpetuity, whereas NRC regulations limit commercial facilities on the time frame for taking credit for oversight to 100 years. DOE also does not use a Class A, B, C, or greater than Class C classification system, which simplifies its waste class determinations through averaging.

With respect to the "carry-away" scenario, a major intent of the NRC's 1995 BTP was to protect the inadvertent intruder from gamma-emitting hot spots in discrete waste types, including encapsulated sealed sources and neutron-activated metals. In revising and updating the BTP, staff conducted additional analyses and determined that, to protect an inadvertent intruder, the staff continues to believe that gamma-emitting hot spots in encapsulated materials and other discrete waste forms should be limited. NRC uses a gamma-emitting sealed source carry-away scenario, to set generic, look-up limits, to protect the inadvertent intruder from gamma-emitting hot spots. The 1995 BTP established this precedent for a separate scenario, and it has been in use since that time. The revised BTP has used a more realistic scenario that results in higher activity limits for disposal of sources and small discrete items.

The International Atomic Energy Agency (IAEA) holds a view similar to the staff and states that:

> *"…activity concentration [limits] that would be suitable for bulk amounts of waste will, in general, not be adequate to classify disused sealed sources."* (Section A.10 of IAEA, 2009)[17]

7. Volume for Averaging:

   a. NRC has previously approved, in a topical report, larger volumes than 0.2 m^3 (55 gallons) for disposal of waste in a non-radioactive medium.[18] The current BTP limits

[17] International Atomic Energy Agency. General Safety Guide, GSG-1, *Classification of Radioactive Waste.* Vienna, Austria.

[18] In December 1999, NRC approved via a Technical Evaluation Report (TER), the Topical Report (TR) Addendum, DT-VERI-100-NP/P-A, Revision 1, Addendum 1, "ENCAP™ Encapsulation Utilizing the VERITM Solidification Process" submitted by Diversified Technologies (DT). In the TER, the NRC approved DT's rationale for encapsulating cartridge filters in 200 ft^3 liners. The rationale presumed the

the volume, however, to 0.2 m^3 (55 gallons). NRC should allow for larger volumes, consistent with its previous approvals. Certain minimum waste loadings could be specified to eliminate the concern over using extreme measures to reduce the waste concentrations. This approach could also be applied, e.g., to disposal of reactor vessels with the internals grouted inside the vessel, as was done for the Trojan reactor.

Staff Response:

The staff has revised the BTP to state that averaging approaches previously approved by NRC in Topical Reports may be used by licensees, subject to the use of the process in the topical report and the specific conditions in the approval. The staff believes that the BTP needs to continue to apply constraints on the amount of averaging using encapsulation, and to allow for these previously approved exceptions. Future approvals of averaging approaches different from those in the BTP would also be acceptable for use. The commenter has requested that only the waste loading be used a criterion for averaging in general, allowing for an unlimited range of concentrations of individual items within the mixture and removing the Factor of 2 and Factor of 10 constraints that are applicable to mixtures of items in containers.

Concentration averaging and classification for items such as reactor vessels with internals grouted in place for disposal should be evaluated and approved on a case-by-case basis by the appropriate regulatory agency. Past regulatory approvals for disposal can be referenced in these requests.

8. Other:

a. The dose standards for re-entry of populations into contaminated areas after an accident are higher (20 mSv/yr (2 rem), e.g.) than 5 mSv/yr (500 mrem/yr), the dose limit that is used for intruder protection. NRC should consider this area in deciding on an acceptable risk for an intruder at a LLRW disposal site.

Staff Response:

The NRC's guidelines for the LLRW classification system specifically addressed limiting potential exposures to an inadvertent intruder who might hypothetically pursue activities at a closed LLRW disposal facility following loss of institutional control. In the FEIS for Part 61, a dose guideline of 5 mSv/yr (500 mrem/yr) to the whole body was determined to acceptable for protection of an inadvertent intruder. Dose standards for post accident conditions are not expected to be appropriate for existing Part 61 land disposal requirements because there is a difference between dose limits appropriate for planned potential exposures and exposures appropriate in response to emergency situations (ICRP 2007). This distinction occurs because the intrusion, if it occurs, will occur decades to hundreds of years after closure of the facility. Therefore, the NRC cannot rely with the same degree of confidence on a

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dilution factor for one filter cartridge encapsulated in a 55-gallon drum (0.2 m^3 – the current BTP limit) is 7.35, which corresponds to a packing efficiency of 13.6%.

future radiological protection organization being aware of the intrusion to take measures to reduce exposures, as it would for an incident resulting in environmental contamination from an operating licensee. However, the NRC staff did consider that the dose limit the commenter recommends (i.e., 20 mSv/yr [2 rem/yr]) is the upper limit of doses the IAEA recommends may be managed by limiting the probability of intrusion (IAEA, 2011) and is consistent with the ICRP guidance that doses below 100 mSv/yr (10 rem/yr) do not necessarily require intervention (ICRP 1998) (See BTP Section 4.2).

b. The Part 61 waste classification system and the BTP scenarios are based on a 100 year institutional control period. Part 61 states that institutional controls cannot be relied on 100 years after closure of a disposal facility. This time period should be revisited because it is unnecessarily conservative.

Staff Response:

The commenter notes that this constraint on reliance on institutional controls is contained in the existing regulations. The BTP is designed to provide guidance on how to implement the current 10 CFR Part 61 averaging provisions for waste classification. In developing a proposed rulemaking to revise Part 61 to address site-specific intruder assessments, a task that is ongoing, the staff has received suggestions from stakeholders that a longer institutional control period be incorporated into 10 CFR Part 61. The staff will consider whether other revisions to 10 CFR Part 61 might also be appropriate, including a longer institutional control period. It should also be noted that the limitation on reliance on institutional controls only applies to Class A waste. Class B is stable waste that maintains its integrity so as to protect the intruder for 300 years. Class C relies on an engineered barrier or a greater depth of disposal to prevent intrusion for 500 years.

c. The draft BTP should use SI units consistently throughout.

Staff Response:

The staff agrees and the BTP has been revised accordingly.

d. Section 3.9 [now Section 4.9] of the BTP, "Alternative Approaches for Averaging," provides examples of averaging that differ from the position in the body of the BTP, and that could be approved under certain circumstances. The staff should keep this section in the BTP and not revert back to having all alternatives to the BTP to be approved under 10 CFR 61.58. The alternatives presented in the revised BTP are implementable and it is expected that Agreement States will be open to their use.

Staff Response:

The staff agrees with the commenter. A further reason for the new section is that 10 CFR § 61.58 is designed to be used to authorize alternative *requirements* for waste classification or waste characteristics provisions. It was not intended for alternatives to NRC guidance, such as is contained in the BTP.

It should also be noted that the NRC is currently developing a rule that will require the performance of site-specific performance and intruder assessments for disposal facilities licensed under 10 CFR Part 61. These assessments are necessary to ensure that disposal facilities continue to meet the performance objectives in 10 CFR § 61.41, "Protection of the general population from release of radioactivity," and § 61.42, "Protection of individuals from inadvertent intrusion." Such assessments could show that the actual designs and engineered barriers in use at disposal sites could ensure protection of an intruder for concentrations of waste greater than those authorized by the license for a given waste class. Currently, either a 10 CFR § 61.58 approval or an exemption from the waste classification requirements in the license would be needed to enable disposal of such materials. The ongoing rulemaking could change the current approval mechanisms.

e. For Section 3.9 [now Section 4.9] of the BTP, "Alternative Approaches for Averaging," the staff should review the examples to determine if any can be placed in the body of the report as acceptable averaging approaches. Using an alternative approach would require a regulatory review, whereas approaches in the body of the BTP would not.

   Staff Response:

   The staff has reviewed the alternative approaches and included two in the body of the revised draft—the use of previously approved topical reports for justifying waste loadings in encapsulation media, and the classification of cartridge filters as homogeneous wastes.

f. Section 3.9 [now Section 4.9] of the revised draft BTP, "Alternative Approaches for Averaging," contains a section entitled "large components." This section provides an example for such an approval, the disposal of the Trojan nuclear power plant reactor vessel. The body of the BTP, rather than the alternative approaches section, should recognize this as an acceptable practice, since it has already been approved. Disposal of large components, particularly a reactor vessel with its internals grouted into the vessel, has the potential to significantly reduce occupational doses from not having to cut up the internals.

   Staff Response:

   Table C in Section 4.5 of the BTP identifies the volumes over which waste may be averaged. The staff has added language to clarify that the term "contaminated materials" may include large components such as pressurizers that contain radioactivity on or near the surface in a fixed or removable condition. With respect to reactor vessels or other large components that would have other types of waste, such as activated metals grouted into them, the staff continues to believe that these should be handled on a case-by-case basis. As noted in the WA State Technical Evaluation Report for the Disposal of the Trojan Reactor Vessel, (Fordham, 1998), there are a number of unique issues associated with disposal of a component or vessel with other highly radioactive components grouted into its volume. Thus, the staff believes that a regulatory review is appropriate.

g. The alternative approaches section of the BTP should more fully reflect a risk-informed philosophy. For example, a 10-meter depth is presented for excluding consideration of the sealed source carry-away scenario, without future elaboration or justification.

Staff Response:

Wastes buried 10 meters and deeper are beyond the typical range of residential human excavations (basements, septic systems, etc.), and the exact depth of 10 m is based on the staff's judgment. A new section has been added to the alternative approaches section that specifies criteria for performing site-specific intruder assessments. Site-specific approaches are more risk-informed than the generic approaches that are the bases for the positions in the body of the BTP.

References:

IAEA, Disposal of Radioactive Waste Specific Safety Requirements IAEA Safety Standards Series SSR-5. 2011

International Commission on Radiological Protection (ICRP), "Annals of the ICRP Publication 81, radiation protection recommendations as applied to the disposal of long-lived solid radioactive waste," Volume 28, No. 4, 1998.

International Commission on Radiological Protection (ICRP), "Annals of the ICRP: 2007, Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. 2007

Koffman, L; Patricia Lee, P; Jim Cook, J; et.al. "Automated Inadvertent Intruder Application," Savannah River National Laboratory, report number WSRC-STI-2007-00295. May 29, 2007.

NCRP 2005, NCRP Report No. 152, "Performance Assessment of Near-Surface Facilities for Disposal of Low-Level Radioactive Waste Recommendations of the National Council on Radiation Protection and Measurements," December 31, 2005

NRC, 1994, Denial of Petition for Rulemaking submitted by the New England Coalition on Nuclear Pollution (Docket No. PRM-61-2). March 29, 1994. ADAMS Accession No. ML093490607)

Tran, P. and James, D., "EPRI Takes on Low-Level Waste Disposal Issues, Radwaste Solutions," EPRI, May/June 2008, pp 14-21, June 2008.

Appendix E: Analysis of Comments Received from Agreement States and LLRW Forum

Background:

NRC received formal comments from the four States that regulate LLRW disposal facilities (Washington, South Carolina, Utah, and Texas) and the LLRW Forum in February 2012. Each of their comments is addressed in this Appendix. The staff is treating their comments separately because the Agreement States are co-regulators of disposal of LLRW under the Atomic Energy Act of 1954.

Stakeholder Input:

The following are the documents related to the States and compacts input on the draft revision (Rev. 1) to the Concentration Averaging BTP. Sited State comments were also included in the February 20, 2012, letter from the LLRW Forum, but are addressed only in the responses to the sited States' letters below.

Document Type	Author	Date	Organization	ADAMS ML #
Letter	Rusty Lundberg	February 17, 2012	Utah Department of Environmental Conservation	ML120520498
E-mail	Susan Jenkins	February 17, 2012	South Carolina Department of Heath and Environmental Control	ML120520496
E-mail	Susan Jablonski	February 17, 2012	Texas Commission on Environmental Quality	ML120530077
E-mail	Earl Fordham	February 17, 2012	Washington Office of Radiation Protection	ML120520505
Letter	Leonard C. Slosky	February 20, 2012	Low-Level Radioactive Waste Forum	ML120530573

Analysis of Comments:

The staff analyzed the comments received in the sections below. The comments are grouped by organization. Each issue is described, analyzed, and a staff conclusion or resolution of the issue is presented.

South Carolina Department of Health and Environmental Control

1. Waste blending:

   a. The allowance for blending waste is not expected to have a practical effect on disposal at the Barnwell Disposal Facility. Facility operations are such that all classes of waste (A, B, and C) are disposed in a manner that meets disposal requirements for Class C waste. State regulation requires the use of vaults for all classes of waste. The vaults function as an engineered intruder barrier and also provide structural stability. Disposal site criteria requires that Class A waste that has a concentration greater than 1 microCi/cc [37 MBq/cc] of any radionuclide with a half-life greater than 5 years is required to be stabilized (typically by solidification or use of a high integrity container). This waste is referred to as Class A Stable. Class A waste not requiring stabilization is referred to as Class A Unstable. The Disposal Site Criteria prohibits acceptance of absorbed liquids regardless of waste classification. All liquids must be solidified. (Incidental liquids are allowed up to 1 percent of the waste volume for stabilized waste and up to 0.5% waste volume for waste that is not stabilized.) Furthermore, all waste (other than irradiated hardware components) regardless of waste class is now disposed of in the same trench and is only segregated by placement in different vaults.

      Staff Response:

      The staff appreciates the State's summary of how its disposal requirements are more restrictive than the guidance offered by the BTP, which is not required to be used by the States.

2. Factor of 10 constraint for classifying a mixture of activated metals involving radionuclides other than primary gamma emitters:

   a. The Disposal Site Criteria implements the Barnwell Rule of 10. The Barnwell Rule of 10 is used to compare whole irradiated components for acceptability in blending waste within each package to meet the Class C concentration limits. The Barnwell Rule of 10 must be satisfied in addition to requirements in the 1995 BTP.

      Staff Response:

      The staff recognizes that the Barnwell rule of 10 is different from the guidance in the current and proposed revised BTP. Because the BTP is NRC guidance, Agreement States are not required to recognize the positions in the BTP.

b. In addition to the 1995 BTP and revised BTP requirements, the Barnwell Rule of 10 requires that all components of the same type must have 10 CFR Part 61, Table I and Table II sums of the fractions within a factor of 10. Likewise, components of different types must have averaged batch Table I and Table II sums of the fractions within a factor of 10.

   Staff Response:

   The staff acknowledges that the Barnwell Rule of 10 is somewhat different from the positions in the BTP, and that the State has authority to impose this different position on its licensee. As stated previously, however, the BTP is a guidance document only, and does not contain any requirements.

c. It is SC DHEC's understanding that all NRC licensees have agreed to adhere to the Barnwell Rule of 10 when classifying hardware shipments for disposal at the Barnwell Disposal Facility.

   Staff Response:

   NRC licensees shipping waste to the Barnwell facility for disposal are required to meet the applicable conditions in the Barnwell license, such as those regarding waste classification.

d. The new BTP may allow a few additional pieces of hardware (of higher concentration) to be disposed compared to current guidance but the effect is expected to be minimal compared to the continued adherence to the Barnwell Rule of 10.

   Staff Response:

   The staff notes the comment. The revisions to the BTP were intended to be incremental, and to not significantly affect current practice for mixtures of items. The State is confirming that this goal has been met for hardware.

3. The significant increase in the sealed-source activity limits:

   a. This revision would have minimal effect on disposals at the Barnwell Disposal Facility. The license requirements for sealed source disposal at Barnwell are more stringent than the 1995 BTP. For example, the license limits disposal of sealed source containing any Table 2 radionuclide (including Cs-137 and Co-60) to a maximum activity of 10 Ci [0.37 TBq] per container. Variances up to the limit of the 1995 BTP may be approved on a case-by-case basis. A variance allowing disposal of unlimited activity of Co-60 and up to 130 Ci [4.8 TBq] of Cs-137 would be at least 13 times the current license limit as opposed to 3 times the limit. There are no plans to amend this condition of the license.

      Staff Response:

      The staff acknowledges this comment.

b. Increasing the maximum activity for Co-60 (unlimited) & Cs-137 (130 Ci) [4.8 TBq] that may be encapsulated into a single package increases the associated dose rates. The increased dose rates will likely change the handling of the sources by workers (generators, processors, shippers, disposal operations) in order to maintain doses ALARA. Also in order to meet the DOT requirements, these encapsulated sources will likely require additional or more robust shielding for the associated dose rates.

   Staff Response:

   The staff acknowledges the State's comment and recognizes that changes in some of the positions in the BTP, if recognized by the States, might prompt other changes in licensees' programs. Disposal of larger activity sources would also have other impacts, such as reduced worker exposures from not having to inspect sources in storage because there is no disposal option, an improvement in security of sources by providing for a disposal option, and so forth. Whatever changes in licensee programs that result from use of the revised BTP positions must also meet the 10 CFR Part 61 requirements.

c. Such an increase would also increase disposal site inventory which could affect a disposal facility's ability to meet performance objectives depending on total activity received.

   Staff Response:

   The staff agrees with the comment. Disposal facilities must meet the 10 CFR Part 61 performance objectives, including 10 CFR § 61.41 for limiting radiation exposures to members of the general public. Any increased inventory that is not within the previously approved limits must be evaluated to ensure that a facility continues to meet the 10 CFR § 61.41 performance objective.

d. Disposal fees and taxes at the Barnwell Disposal Facility are based on volume, not activity. An increase in the maximum activity for sealed sources per container would mean more source term for the Disposal Facility with no corresponding increase in funds for long-term care at the facility.

   Staff Response:

   The staff notes the State's comment. The State can determine the means by which funds are collected for long-term care of the facility. With respect to the increase in activity for sources in the BTP, the staff's revised position is based on protection of public health and safety.

4. BTP as guidance:

a. Language in the Disposal Site Criteria (a procedure tied to the license) states "all customers shipping radwaste material to the Barnwell Site shall comply with the US NRC Branch Technical Position on Concentration Averaging and Encapsulation, dated 1/17/95". The Disposal Facility License is currently under appeal and has been since

2004. While the Disposal Site Criteria could be revised to reflect the new BTP without amending the license, it is a decision that will be carefully considered. Since the appeal, the license has only been amended to incorporate more stringent requirements and minor or administrative changes. If the perception is that the new BTP is less stringent, its adoption prior to a final decision on the appeal, may be of concern. Use of the new BTP would be expected to have minimal impact on disposal at the Barnwell Disposal Facility as disposal is limited to generators in the three states of the Atlantic Compact (Connecticut, New Jersey and South Carolina). Also, as described there are several additional site-specific requirements that further limit the effect of increased disposal options afforded by the new BTP.

Staff Response:

The NRC staff acknowledges the State's comment.

5. Public Outreach:

   a. Upon finalization of the revision to the BTP, would NRC consider conducting public meetings in sited states to assist states in addressing concerns of the stakeholders adjacent to the disposal sites?

      Staff Response:

      Yes, the NRC staff believes this would be beneficial and would be willing to conduct or participate in meetings on the BTP revisions with stakeholders in the vicinity of the disposal sites, assuming availability of funds and upon request by the affected States.

6. Enforceability:

   a. We are never able to absolutely verify the waste classification or homogeneity even under the current BTP. We currently must rely on generators' process knowledge and analytical results (typically dose-to-curie conversions using scaling factors). We require the disposal facility to review the paperwork to confirm that the methodology and calculations are satisfactory. Additionally, since about 1997, the Barnwell Disposal Facility is required to forward for SC DHEC review all Class C waste disposal requests whether applying the guidance in the CA BTP or not (although we only require a cover letter describing the request and the classification documentation (i.e., Radman™ analysis) and not the entire voluminous paperwork package). If we have questions after our review, we may ask to see the entire package or other supporting data.

      It would be helpful if a disposal facility's waste acceptance criteria (as approved by the state regulator) required the generator to identify what sections of the guidance in the CA BTP, if any, are being applied in the waste classification process for each waste package. It could be in the form of a checklist. This is an approach that sited states could use to help identify these waste packages and associated generators thereby providing opportunity for paperwork auditing at the least. Including such guidance in the CA BTP would be helpful to sited states as well.

Staff Response:

The staff acknowledges this comment and several others by States in which the issue of obtaining additional assurance in the waste classification performed by waste generators and processors shipping to disposal facilities is raised. As the State has noted, this issue is not unique to the revised BTP. Currently, the paperwork required of generators shipping waste to a disposal facility is specified in Appendix G, 10 CFR Part 20, the uniform manifest provisions. The staff cannot require additional paperwork with a shipment without changing the rule.

The staff is aware of at least several tools that sited States can use to have reasonable assurance that waste is classified correctly. These include:

- The Washington Department of Health (DOH) began the Point-of-Origin Inspection Program in 1992. The goal of the program is to identify any deficiencies at generator facilities prior to waste being shipped for disposal. Identifying deficiencies before the waste is shipped will reduce subsequent packaging or waste form violations upon receipt at the commercial LLRW disposal site. DOH achieves this goal through random inspections of generator facilities. Washington is currently the only state in the nation that conducts point-of-origin inspections. This program was used as a basis for a Model Inspection and Verification Program (DOE/LLRW-185) that was developed as guidance for other states.

- The Utah Department of Environmental Quality implements a Generator Site Access Permit program that provides additional assurance that generators have classified their waste appropriately. See Utah Radiation Control Rules R313-26.

- The U.S. Department of Energy published a report, “Methods for Verifying Compliance with Low-Level Radioactive Waste Acceptance Criteria,” (DOE/LLRW-185) that may also have useful information. This report was based on the Washington Department of Health generator inspection program.

- Waste Controls Specialists has developed a Waste Acceptance Plan that addresses oversight of waste generators’ classification of radioactive waste. The State of Texas has authority to oversee the implementation of this plan.

The Agreement States regulate all of the LLRW disposal sites in the United States, and as noted above, have implemented several requirements to obtain assurance that generators classify waste appropriately. The staff believes that the States, given their experience in implementing the BTP, are in a better position to address this issue, by, for example, incorporating requirements into the disposal facility waste acceptance criteria. To the extent that the BTP can provide useful guidance on this topic, the staff is open to suggestions for specific language that might be added to the BTP. The staff is also willing to participate in discussions with the States on any discussions related to this issue with the goal of providing additional assurance to sited States that waste has been appropriately classified.

b. What level of oversight do NRC resident inspectors at nuclear power plants provide related to low-level waste processing and packaging? What assurances will/can the NRC provide to assure that these various waste types generated at nuclear power plants are in fact homogeneous and processed in accordance with the revised CA BTP?

Staff Response:

NRC's Inspection Procedure for nuclear power plants, 71124.08, "Radioactive Solid Waste Processing and Radioactive Material Handling, Storage, and Transportation," states that the inspections are to verify that power plant licensee's radiochemical sample analysis results (i.e., "10 CFR Part 61" analysis) are sufficient to support radioactive waste characterization as required by 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." Among other things, the procedure directs inspectors to "Verify that the licensee's use of scaling factors and calculations to account for difficult-to-measure radionuclides is technically sound and based on current 10 CFR Part 61 analysis." The inspectors do not solely use the BTP as a means of verification.

NRC Inspection Procedure 86750, "Solid Radioactive Waste Management and Transportation of Radioactive Materials" also contains guidance for NRC inspectors of nuclear power plants on waste classification by licensees.

The staff is willing to discuss NRC oversight in connection with the States' desire for increased assurance of generator waste classification, as noted in response to comment 6.a.

c. Would upper level managers at generator facilities be willing to provide certification statements certifying that approved waste classification procedures were followed and BTP guidance was strictly adhered to?

Staff Response:

The information contained in response to comment no. 6.a should be helpful for this particular issue. Agreement States can impose restrictions on generators and processors that ship waste to disposal facilities in their State. It should be noted that NRC's regulation for waste manifesting in Appendix G, 10 CFR Part 20, requires that the waste be certified as properly classified, packaged, marked, labeled, and in proper condition for transportation. The certification is to be signed and dated by the person responsible for the packaging and labeling operations. The person must also be authorized to sign on behalf of the shipping company or thefacility.

7. Performance Assessment:

a. The current PA for the Barnwell Facility took several years to complete. After discussions with NRC, SC DHEC convened a Blue Ribbon Panel of experts to provide a third party review of the "Environmental Radiological Performance Verification" submitted by the disposal facility. SC DHEC monetarily compensated the panel for their review. Costs were in the ballpark of $25,000. Would NRC be willing to assist states in the review of future performance assessments either by providing funding for such third party reviews or providing staff support? Increases in license fees to pay for such reviews are not likely to be approved with the current economic environment.

Staff Response:

NRC would not be able to provide funding for third party reviews, but could potentially provide staff assistance for such reviews. NRC Management Directive 5.7, “Technical Assistance to Agreement States,” describes the types of assistance NRC provides to Agreement States.

8. Benefit to very large generators

    a. As stated previously, the current disposal facility license is more stringent than the 1995 BTP with regards to sealed source activity. Disposal is limited to 0.35 Bq (10 Ci) per container without special approval. Currently in SC, there are only three licensed Cs-137 sources greater than 0.35 TBq (10 Ci). There is one licensed source between .35 TBq (10 Ci) and 1.1 TBq (30 Ci), one between 1.1 TBq (30Ci) and 4.8 TBq (130 Ci), and one that is greater than 4.8 TBq (130 Ci). The first two would require special approval for disposal at Barnwell even under the new BTP. (We have not collected information from Connecticut and New Jersey - the other states in the Atlantic Compact). What is expected to be the impact to sited states as far as number of sources that potentially will be disposed based on the new guidance compared to the current? If it is a small number, could these be approved on a case-by-case basis instead?

    Staff Response:

    The staff determined that the sealed source activity limits can be safely increased in the BTP to facilitate disposal of a significant number of sources. For example, the DOE Offsite Source Recovery Project (OSRP) stated in its April 18, 2011, letter to NRC that the current BTP is having the unintended result of preventing a large number of non-GTCC radioactive sources from being disposed of in commercial LLRW disposal sites. It noted that these sources are some of the sources that are of greatest concern from a national security perspective. Aside from sources in storage at the OSRP, commercial licensees have more than 2000 Category 1 and 2 Cesium 137 sources currently in use that will eventually be retired and need a disposal option. Nearly 200 are between the 1995 BTP recommended limit of 1.1 TBq (30 Ci), and the revised BTP recommended limit of 4.8 TBq (130 Ci). Future users of sources will need disposal options as well.

    With respect to the use of alternative approaches, as noted above the number of sources is not small, and a large number of case-by-case approvals may be needed. In addition, given the potential national security issues associated with sealed sources, the staff believes that the process for authorizing disposal should not only be safe, but also efficient. The BTP’s position that sources below a certain activity can be safely disposed of in any disposal facility, based on the generic analysis in the Appendix B of the BTP, will facilitate the safe disposal of the sources and eliminates the need for a case-by-case review.

9. Alternative Approaches:

   a. In general, the allowance for the use of alternative approaches can be positive for regulators. Regulations/guidance that are too specific and too rigid are not easily adaptable to unforeseen/unique situations. For example, the EPA's hazardous waste regulations are very prescriptive making it difficult to find solutions to complex problems at some facilities. It can be helpful to have the option of another approach in unique situations where the benefits for clean-up, decommissioning, ALARA, etc. outweigh the other factors being considered and provide the same or greater protection of the environment/health the state/public.

      Staff Response:

      The staff agrees.

<u>Office of Radiation Protection, Washington Department of Health:</u>

1. Although BTP is only guidance, in Washington the BTP is incorporated into the license thus making the BTP part of the waste acceptance criteria (WAC). As such, broad statements in the BTP need examples or further detail so site operators as well as disposal site state regulators can ensure an equivalent level of understanding with NRC staff intentions.

   Staff Response:

   The staff agrees and has attempted to provide detailed guidance, as discussed in the comment response below.

2. In Section 3.1 (now Section 4.1), what kind of "mixtures" does the NRC believe will be produced under this CA BTP (if adopted as is)? Suggest you add what mixtures (e.g., Class B/C resins mixed with Class A) are anticipated to the BTP.

   Staff Response:

   Based on a recent industry proposal, the NRC staff expects that ion exchange resins with different radionuclide concentrations may be blended to create Class A waste, as the commenter suggests. The BTP text has been revised to include this example.

3. Disposal sites only get limited data on the NRC Forms 540, 541 and 542. With the demands of the CA BTP (e.g., gamma controlling radionuclides, x10 within class limit, sizes < 280 cc ($0.01 ft^3$), site operators/state regulators need additional methods to verify compliance. Does the NRC envision the site operators/sited state regulators being able to verify compliance? If so, how? Or does the NRC default to the generators (Section 3.7 [now 4.7]) and generator state regulators?

   Staff Response:

The staff appreciates the sited States' desire to have more assurance and/or documentation that waste has been appropriately classified before shipment to the disposal facility. This issue is not new or associated with the revisions to the 1995 BTP. The staff is aware of steps that sited States have taken to gain assurance that waste is classified appropriately, such as:

- The Utah Department of Environmental Quality implements a Generator Site Access Permit program that provides additional assurance that generators have classified their waste appropriately. See Utah Radiation Control Rules R313-26.

- The Washington Department of Health (DOH) began the Point-of-Origin Inspection Program in 1992. The goal of the program is to identify any deficiencies at generator facilities prior to waste being shipped for disposal. Identifying deficiencies before the waste is shipped will reduce subsequent packaging or waste form violations upon receipt at the commercial LLRW disposal site. DOH achieves this goal through random inspections of generator facilities. Washington is currently the only state in the nation that conducts point-of-origin inspections. This program was used as a basis for a Model Inspection and Verification Program (DOE/LLRW-185) that was developed as guidance for other states.

- Waste Control Specialists' Waste Acceptance Plan for generators.

In addition, the U.S. Department of Energy (DOE) published a report, "Methods for Verifying Compliance with Low-Level Radioactive Waste Acceptance Criteria," (DOE/LLRW-185) that may also have useful information. This report was based on the Washington Department of Health generator inspection program.

NRC staff is willing to consider adding language to Section 3.7 [now 4.7] of the BTP in the final version of the BTP addressing how Agreement States with disposal facilities can obtain a higher level of assurance of the classification of waste. The staff is also willing to discuss potential changes to the BTP to address this issue before the States submit any suggested additions.

4. The manifest waste descriptor "Contaminated materials" is a very broad term (e.g., similar to DAW) and should be avoided. In fact, under the new blending concepts, isn't all material in the disposal package supposed to be "(radioactively) contaminated"? As such, this waste descriptor would be added to every package listed on the manifest. Waste descriptors on disposal manifests should relate to the BTP and waste acceptance criteria categories. I recommend more specificity in waste descriptors for the benefit of site operators and state regulators.

   Staff Response:

   The manifest waste descriptors contained in line 11 of Form 541 do not mean "contaminated materials" as used in the BTP. The BTP defines that term as " . . . typically involve[ing] components or metals on which radioactivity resides near the surface in a fixed or removable condition." This term was not carried over into the draft revision, but has been added to the current draft. Thus, in the context of the BTP, it has a narrow meaning and is not meant to be used as a substitute for the waste descriptors on Form 541. The staff does not believe that any changes are warranted since this BTP term has been in use for 17 years.

5. Why are “absorbed” liquids still mentioned in the BTP? Does any site still dispose of sorbed (onto an approved agent) liquids? I believe the disposal facilities require solidification or stabilization of liquids.

   Staff Response:

   The staff reviewed existing disposal facility licenses and determined that absorbed liquids are authorized in some cases. The staff does not know the extent that this waste form is used in practice, but believes that because it is authorized, it should continue to be addressed in the BTP.

6. In Section 3.2.1 [now 4.2.1], page 10, last paragraph, hot spot detection is discussed. How is detection done? “*If*” seems to be a key assumption in the phrase, “*If* it is detected in a container ….” Also, how would you know if it is less than or greater than 10 times the class limit?

   Staff Response:

   Section 3.2.1 of the August 2011 draft BTP [Section 4.2.1 in the May 2012 draft] addressed waste streams that are presumed to be homogeneous, for which no testing is necessary to demonstrate homogeneity. The guidance discussed certain actions a licensee could take if a hot spot was detected during the course of characterization for some other purpose (e.g., for transportation). The term “if” was used because it was not assumed that licensees would verify homogeneity in these wastes. In the draft, it was envisioned that hot spots may be detected during package surveys. It was further assumed that a licensee would be able to determine if the hot spot was likely to have concentrations more than 10 times greater than the relevant class limit based on knowledge of the class of the waste package and scaling factors. As discussed in more detail in response to Comment 1 in Appendix D, the NRC staff has determined that it is unnecessary and inconsistent with ALARA principles to specify any additional actions for licensees to take if hot spots are detected in waste that is designated as a homogeneous waste type. Therefore, the text to which the commenter refers has been removed from the guidance.

7. It is not uncommon to find a hot spot on the outside of a disposal package. What additional measurements (p 11, last paragraph of Section 3.2.1) should be made on the disposal package to confirm its waste class? Perhaps an example and further explanation would be helpful. At the Washington LLRW disposal facility, the state’s inspector could perform an internal package inspection to identify the reason for any “hot spot” if health physics calculations indicated high activity levels.

   Staff Response:

In the August 2011 draft BTP, the NRC staff indicated that additional measurements may need to be taken to verify the waste class if a hot spot would cause the average sum of fractions in a package to approach a class limit. A hot spot detected in a package far below the class limit may trigger no additional measurements. In noting that additional measurements may be necessary, the NRC staff envisioned that additional survey readings could be made to attempt to define the size and concentration of the hot spot. However, as discussed in more detail in the response to Comment 1.g in Appendix D, the NRC staff has removed some of the specific guidance related to uncertainty in waste class calculations from the BTP, including the text the commenter notes. As the commenter indicates, it is not uncommon to detect hot spots on the outside of a disposal package. The NRC staff expects that licensees will continue to follow their current quality assurance procedures related to waste class calculation (see Section 4.7). As originally noted in the 1983 Waste Classification Technical Position (NRC, 1983), more sophisticated waste classification programs should be used for waste for which minor process variations may cause a change in waste classification.

8. In Section 3.2.2 (page 11), the BTP says approval to blend dissimilar flowable waste streams should be handled on a case-by-case basis. In this vein, I suspect generators will blend Class B ion exchange resins and slightly contaminated Class A soil-like material to maximize the load/minimize voids and reduce disposal expense. Will this layer blending increase the risk to the inadvertent intruder?

   Staff Response:

   Mixing physically dissimilar waste streams is not expected to increase the dose to a potential inadvertent intruder. In general, horizontal layering is not expected to affect the dose to an inadvertent intruder because it is assumed an intruder will be exposed to a vertical cross section of waste. If waste layers horizontally, any vertical cross section will reflect the average concentrations in the waste package. Mixing wastes with significantly different radionuclide concentrations is of greater concern if the waste is not well mixed or does not stratify into relatively uniform horizontal layers, but instead retains pockets of waste with elevated concentration. Blending of physically or chemically dissimilar waste could present a hazard if the wastes are chemically reactive (e.g., if they generate hydrogen gas). In response to comments from ACRS, the NRC staff added text to the BTP to specify that the chemical compatibility of waste streams should be verified before blending.

9. The BTP mentions several timeframes: 100 year (DAW to achieve ‘soil-like’ properties), 300 years (stable waste forms to maintain gross physical properties and identity) and 500 years (when inadvertent intrusion is hypothesized). When do these timeframes start? Upon waste disposal, trench closure, site closure or some other time?

   Staff Response:

   The timeframes in the BTP are consistent with the timeframes used in the Environmental Impact Statement (EIS) for 10 CFR Part 61. The EIS states that inadvertent intrusion occurs after the facility closes and active institutional control and surveillance over the facility have been removed. The timeframes of 100, 300 and 500 begin once the site is closed and the institutional control period begins.

10. Claiming statistics exist for waste in a package can be difficult. A sum of fractions minus the standard error is very difficult even for packages containing only one waste stream as these streams are typically only sampled annually. Most waste streams are only small fractions (e.g., 1 – 5%) of the Class A limit thus sample error is not critical. Gamma-controlling waste can easily approach waste class limits, but can be difficult to sample sufficiently to achieve adequate statistics.

    Staff Response:

    The NRC staff agrees that the proposed restriction on the uncertainty in waste classification calculations in the August 2011 draft BTP could be difficult to implement and contrary to ALARA principles. The NRC staff has significantly revised this section of the draft BTP and assumes that licensees will use existing quality assurance programs for waste classification (see Section 4.7)

11. In Section 3.9 [now Section 4.9], under the *Likelihood of Intrusion* section, discussion allows a probability of intrusion less than one. With Washington's LLRW disposal site on federal government land, what documentation is needed to use a probability of intrusion less than one in a site-specific performance assessment?

    Staff Response:

    As stated in the draft BTP, there is no scientific basis for predicting the nature or probability of future human activities. For this reason most LLRW inadvertent intruder exposure assessments, such as those used in the DEIS for Part 61 and those used to derive limits for the 2011 draft revised BTP, use "reasonable, yet conservative" exposure scenarios, with a probability of one, to set limits to protect the inadvertent intruder. That said, on a site- and/or a waste-specific basis it may be possible to rule-out certain human activities based on the physical characteristics of the site or the waste form. For example, a domestic groundwater well can be excluded from consideration if the salinity of local groundwater is too high to drink or there is a clear lack of groundwater resources in the area. Further, durable, government controls may be cited as justification for a reduced likelihood of intrusion at least in the near-term. However, many experts have considered the durability of government controls (EPA 1985; Hora, S.C., et al, 1991; NRC 1982; NAS 1995) and all have concluded that government controls cannot be relied upon exclusively for long timeframes. Because there is no scientific basis for predicting the nature or probability of future human activities, the NRC does not recommend relying solely on probability arguments as justification to dispose of higher specific activity LLRWs. The NRC recommends that evidence, concerning the probability of inadvertent intrusion, coupled with additional waste- and/or site-specific factors, may be used together as a "defense in depth" justification for exclusion of certain intruder scenarios.

12. On page 5, 3rd paragraph, the BTP mentions "number of well-publicized accidents". Can these accidents either be footnoted or briefly mentioned in the paragraph as to how they influenced this BTP?

    Staff Response:

A footnote with the requested information has been added to the BTP section referenced above.

Utah Division of Radiation Control

1. Increase in Sealed Source Activity

   a. The 1982 NRC Final EIS was able to eliminate certain intruder scenarios on the basis that if future excavation exposed a drum of waste, the intruder would recognize it as artificial. The 1995 NRC Concentration Averaging BTP built on this intruder-discovery scenario by assuming a Cs-137 sealed source 1.1 TBq (30 Ci) was centered in a 0.2 m^3 (55 gallon) drum and encased with cement grout at the time of disposal. … ”

      Staff Response:

      The staff agrees. In 1995 and in the revised draft of the BTP, the staff has postulated different and more conservative scenarios than the intruder-discovery scenario in the DEIS, i.e., in both cases, NRC has postulated that an intruder does not abandon his activities within a short period of time of discovery of a discrete item (as assumed in the DEIS), but continues to be exposed for long-periods of time. In this sense, both the 1995 and revised draft have “built on” the scenarios in the DEIS for 10 CFR Part 61. The exposure parameters are somewhat different for the two versions of the BTP, resulting in a higher Cs-137 activity limit in the revised draft.

   b. We are concerned about the dramatic increase in the allowed sealed source concentration limit, e.g., from 1.1 TBq (30 Ci) to 4.8 TBq (130 Ci) for Cs-137. While we recognize that the August 2011 draft BTP was based on a “carry-away” scenario, it is unclear how a sealed source concentration limit could be derived, given that:

      - Less Shielding Present—considering short term direct skin contact with the source (and not the drum) for 4 hours while in transit to the residence [an assumption used in the revised draft of the BTP] and the longer term exposure , less dense intervening materials (less than cement) to shield the intruder while inside his/her residence.
      - Greater exposure time—in that now the intruder would reside in the home for about 16 hours/day for many years, and not 8 hours during a temporary excavation project.

      Additional explanation and justification seems warranted to address the increased sealed source concentration limit. Careful coordination is also needed to ensure the back-calculations are consistent with the inadvertent intruder scenarios.

      Staff Response:

      The staff has used reasonable, yet conservative assumptions for the current draft BTP that are somewhat less conservative than those used in the 1995 BTP. Enclosure 2 of the 1995 BTP describes in detail the assumptions for the radiation exposures. An exposure time of 2360 hours at a distance of one meter was used in both of the scenarios that are the bases for the 1995 BTP positions. Appendix B of the revised draft similarly describes the assumptions for the "carry-away" scenario that exposes the intruder to radiation. The staff assumed that the exposure to a source would be for 4 hours at 3 cm, plus 15 hours/week at two meters. Thus, both the 1995 BTP and revised draft use scenarios that involve lengthy exposure times and which are more conservative than the "intruder-discovery" scenario in the DEIS, which involved an exposure time of only a few hours. The differences in assumptions, as described here and in more detail in the two versions of the BTP, accounts for the difference in recommended limits for sealed source disposal. The calculations for the 4.8 TBq (130 Ci) limit in the revised draft were verified. It should also be noted that if these additional scenarios had not been used, 34 TBq (920 Ci) of Cs-137 could be disposed of as Class C waste when encapsulated in a 0.2 m^3 (55 gallon) drum, using the 10 CFR § 61.55 concentration limits.

c. Sealed sources are of a concern in that they generally constitute large activity, small volume sources of radioactivity, and thus appear to conflict with the original mission and purpose of the Clive facility (large volume, low activity). Thus, increased Class A activity limits resulting from the proposed sealed source disposal have potential to be in conflict with Clive's original mission, and deserve careful consideration. Review of the historic NRC findings on sealed sources is also in order. In the 1981 NRC DEIS the inadvertent intruder analysis concluded that elimination of sealed sources from LLRW classification would result in a decrease of dose on the order of more than 2-orders of magnitude.

   Staff Response:

   The NRC staff is aware that the Clive facility was originally licensed for disposal of naturally occurring radionuclides and bulk waste, and that the license has been amended over the years to accept other kinds of radioactive waste. The State, as an NRC Agreement State, has the authority to amend the license to accept other types of waste. With respect to the BTP, it is NRC guidance and the State is not required to use it.

   With respect to increased Class A activity limits, only one radionuclide in the sealed source tables increased in the revised draft. Cs-137 increased from 111 MBq (0.003 Ci) in 1995 to 266 MBq (0.0072 Ci) in the revised draft. The rest of the radionuclide limits remained the same, except for Co-60, which was significantly reduced.

   With respect to sealed sources, the DEIS analysis for 10 CFR Part 61 included large americium-241 sources which are now classified as greater-than-class C waste and not currently permitted to be disposed of in a 10 CFR Part 61 facility. The high doses modeled in the DEIS from sealed sources were specifically from Am-241, which was modeled at a concentration 3600 times higher than the concentration limit in the final Part 61 regulations. Disposal of sources in accordance with the guidance in the revised BTP will ensure the safety of an inadvertent intruder and compliance with inadvertent intruder performance objective in 10 CFR § 61.42.

d. The decrease in the Class A limit for Co-60 (26 TBa (700 Ci) to 5.2 TBq (140 Ci)) appears to be driven by the new "carry-away" intruder scenario where NRC staff assumed where the intruder comes into intimate contact with the cladded source 100 years after disposal. The removal of any activity limit for Class B or C waste, appears to be largely driven by the isotope's short half-life (5.27 years) and the longer decay time assumed before intruder contact, i.e., 300 and 500 years, respectively; made possible by an assumed lengthy delay for intrusion.

The activity limit increase proposed for Cs-137/Ba-137m for all classes appears to be the product of the same "carry-away" intruder scenario, and related assumptions. No changes were proposed for Nb-94.

Staff Response:

Comment noted.

e. All of these proposed NRC class limits are based on the assumption that the cladded source remains physically intact and sealed for 100, 300, and 500 years, respectively. Given the saline soils and groundwater at the Clive site, it is difficult to conceive this would be the case. Hence, the NRC assumptions behind the proposed sealed source activity limits for gamma emitters appear to be better suited for land disposal in Washington, Texas, and South Carolina, not Clive, Utah.

Staff Response:

Corrosion of cladding on sealed sources (typically stainless steel) would create less of a hazard to an intruder than an intact source. Such corrosion would enable mixing of the radioactive material with soil, and would prevent an intruder from handling a discrete source for an extended period of time, the exposure scenario that is used as the basis for the sealed source limits in the BTP.

2. Factor of 10:

a. This is a more complex classification process and doing away with the Factor of 10 Rule and substituting instead a 2 page,13 step decision tree adds more complexity to waste classification, and provides more opportunities for generators to err. It also places more burden for generators and State regulators to inspect waste treatment and classification.

Staff Response:

The Factor of 10 that was eliminated from the BTP constrained the blending of mixable waste (i.e., non-discrete items). It was replaced with a performance-based homogeneity test, and is reflected in the 1-page 4-node decision process in Figure 3. Most of the decision tree the commenter refers to relates to the classification of discrete items.

In general, the NRC staff understands concerns about the complexity of the BTP and has tried to make the draft revised BTP less complicated than the current 1995 BTP. For example, the 1995 BTP includes separate positions for mixtures of activated metals, and mixtures of contaminated materials, and mixtures of cartridge filters; whereas the 2011 draft of the BTP combines these three sets of guidance into a single position. Additionally the bases for the 2011 positions are all clearly described in Appendix B of 2011 draft BTP, whereas the 1995 BTP does not always justify its positions in Enclosure 2 (e.g., the basis for the Table B values are not described in Enclosure 2 of the 1995 BTP). The 1995 BTP, similar to the current draft, contains a 2 page 14 step decision tree.

3. BTP as Guidance:

   a. The ACRS stated that the CAE BTP sealed source intruder scenario was overly conservative, did not recognize the depth of burial, and that the "carry-away" scenario had already been ruled unlikely in the Final EIS. Further, they concluded that the most appropriate scenario for sealed source disposal was the "discovery-scenario" in the 1982 Final EIS; which is actually an abbreviated version of the dwelling construction scenario from the 1981 DEIS. In this 1981 scenario, excavation workers recognize the waste form is artificial and stop digging. This assumes the drum and encapsulation matrix remain intact. It also denies the habitation/agriculture scenario from ever happening.

      The ACRS also went on to say: *"…the use of overly conservative scenarios "for inadvertent intrusion into presumably abandoned, unmarked, and unsecured LLRW disposal facilities can change the focus of the facility design from the protection of the health and safety of the public during the period of operation of the facility (and a reasonable period thereafter), to the protection of hypothetical intruders many thousands of years in the future."* Unfortunately, the ACRS provided no definition of what it considered a "reasonable period" after disposal.

      At the root of the discussion, it appears the ACRS prefers NRC use a short period of performance, in that they envision the drum and encapsulation matrix is intact, allowing the intruder to easily recognize the waste form is artificial, and prevent exposure. In contrast, NRC staff appears to view the problem in terms of "deep time", and acknowledge the shortcomings in the 1981 DEIS, 1982 FEIS in that the 10 CFR classification system is flawed, as follows:

      - Short Lived Waste Assumption – that LLRW will experience significant decay in 100 (Class A), 300 (Class B), and 500 years (Class C) after disposal. Unfortunately, the current NRC rule fails to acknowledge long-lived isotopes, known to exist in LLRW and power plant wastes, e.g., Tc-99 (half-live = 211,000 years), that will not significantly decay in 500 years or less.
      - Opposite Behavior of Depleted Uranium – where long term ingrowth of decay products increase the risk to the public. This was the mission the NRC staff were charged with by the Commission, as a means to reconcile the Louisiana Energy Services lawsuit.

      So a disparity exists between the NRC staff and the ACRS, that is critical to reconcile before any final NRC rule is revised, adopted, and final guidance issued. From the ACRS letter, it appears the advisory group prefers a shorter 1,000 year period of performance (POP), as is the case with current DOE policy for waste disposal. In contrast, longer time periods are being considered by NRC staff in response to SECY-08-0147.

      Staff Response:

The commenter is addressing two of the performance objectives in 10 CFR Part 61, protection of a member of the public that resides offsite (10 CFR § 61.41) and protection of an inadvertent intruder (10 CFR § 61.42). The BTP addresses concentration averaging, which affects compliance with 10 CFR § 61.42, i.e., protection of an inadvertent intruder only. Thus, some of the concerns identified above are not affected by the positions in the BTP. Each of the specific issues related to intruder protection and compliance with the 10 CFR § 61.42 performance objective is addressed below:

- The BTP addresses protection of an inadvertent intruder over the time frames established for the 10 CFR § 61.55 waste classification system, i.e., up to 500 years. Thus, the NRC staff and ACRS are in agreement on this issue. It should be noted that NRC has initiated a rulemaking that would address in part disposal of large quantities of depleted uranium. This waste stream becomes more radioactive over time and longer time frames for intruder protection will be required. The BTP does not address depleted uranium disposal. Concentration averaging is not expected to be a significant regulatory issue for depleted uranium.
- With respect to other long-lived isotopes, these were evaluated in the DEIS for 10 CFR Part 61 and the existing classification system accounts for their long-lived hazard.
- The staff continues to disagree with the ACRS on the appropriate scenarios for addressing "hot spots" in LLRW, such as sealed sources. The ACRS has recommended that the scenarios used in the draft EIS for 10 CFR Part 61 be utilized, while the staff believes that other scenarios are needed. The 1995 BTP established the precedent for the new scenarios, and in the revised draft of the BTP, the staff has used more risk-informed scenarios that result in higher activity limits for disposal of sealed sources. See Appendices G and H for the ACRS report on the BTP and the staff's response respectively.

It should be noted that there is no requirement that the staff and ACRS agree on the final version of the BTP. The ACRS advises the Commission, and the staff reports to the Commission. The staff will be soliciting stakeholder views on the ACRS recommendations for the BTP and may further address their concerns in the final version of the BTP.

b. The CAE BTP, Section 3.8 [now Section 4.8] describes how the new guidance will allow an off-ramp to the proposed CAE BTP decision tree; largely based on disposal site PA results and intruder analysis. This "off-ramp" is consistent with the current alternative waste classification/characteristics requirements found in 10 CFR 61.58. However, one would expect that in 1982 when 10 CFR 61.58 was framed, it was anticipated that when an alternative was proposed, it would be subject to public notice and comment. However, given now that proposed "off-ramp" is in guidance, which is not mandatory for an Agreement State to follow, a potential situation could exist where either the generator or disposal State (or both) could make a change to a license, without public participation. Under these circumstances, the public would be denied the opportunity to comment. Inversely, if a disposal site PA/intruder analysis is approved by a sited State, and forms the basis for waste packaging/classification in a generator State, does or will this compel the generator State to undergo a public comment period?

Staff Response:

The 1995 BTP stated that approaches different from those presented in that guidance document should be approved by regulators using 10 CFR § 61.58. That provision, however, is designed to be used for alternative *requirements* for waste classification and characteristics, different from those contained in 10 CFR § 61.55 ("Waste classification") or 10 CFR § 61.56 ("Waste characteristics"). The BTP has been revised to be consistent with NRC's use of guidance in its other regulatory programs, i.e., that compliance with them is not required. With respect to public participation, since all of the licensed disposal facilities are regulated by Agreement States, public participation would be determined by State policies and procedures.

With respect to the generator States, the requirements for a public comment period would be defined by the Agreement State in which the generator is located and by whether any changes would be needed in generators' licenses to ship waste to the disposal facility.

c. As laid out in the draft CAE BTP, the first test in the CAE BTP guidance in process is to ask if the waste is "homogeneous or a mixture of items". NRC describes homogeneous waste as (CAE BTP, pp. 5, 9-10):

- Solidified or absorbed liquids,
- Spent ion exchange (IX) resins, filter media, evaporator bottom concentrates, ash, contaminated soil, and
- Dry Active Waste (DAW) , and
- With regard to the "items", that might be mixed into LLRW or are not homogeneous, the NRC CAE BTP (p. 5) mentions:
    - Activated metals (e.g. tools, equipment, large objects, etc.),
    - Contaminated materials,
    - Spent cartridge filters, and
    - Sealed sources.

It is clear that the new NRC guidance addresses a very wide range of LLRW waste types. Examination of these waste types in context of the 1981 NRC Draft Environmental Impact Statement (DEIS) and the 1982 Final Environmental Impact Statement (FEIS) provides some very interesting information. With the exception of "contaminated materials", all of the waste types discussed in the draft CAE BTP were considered in the 1981 NRC DEIS.

Staff Response:

Comment noted. With respect to "contaminated materials," as defined in the BTP, this is a waste type that is considered to be a discrete waste that, like other discrete wastes, posed hazards different from the homogeneous wastes analyzed in the DEIS for 10 CFR Part 61.

4. Benefit to Very Large Generators:

   a. Larger sealed source owners will benefit from the new guidance, and not disposal States. CAE BTP Figure 1 flowchart shows how “coffee cup” sized items with certain activity levels are separated from the waste form, and then undergo another series of tests. In turn, the NRC Figure 2 tests allow “coffee cup” sized items to be diluted by encapsulation and averaging over a larger volume container. This dilution provides a potential for generators to segregate small items with elevated activity and down-grade their classification. Taken to an extreme, GTCC equivalent material could be downgraded to Class C, or Class B/C equivalent materials could become Class A. This potentially would benefit generators with GTCC sources or who are mandated by law to manage GTCC waste.

      Staff Response:

      The encapsulation position in the BTP that provides for averaging of sources and other small items over the volume of a 0.2 m^3 (55 gallon) drum is the same in the 1995 BTP. It is a widely used practice, and provides for stability of the waste, makes movement of the waste by an inadvertent intruder more difficult because of its increased bulk, and provides for improved isolation of the radionuclides from water infiltration. At the same time, the 0.2 m^3 (55 gallon) drum volume limits the amount of credit for averaging. This approach has been widely used by States and is widely accepted as an appropriate waste management practice.

      The revised draft of the BTP increases the allowable source size from 1.1 TBq (30 Ci) to 4.8 TBq (130 Ci) for Cs-137, e.g., still well below the 34 TBq (920 Ci) limit that would be allowed using the Class C limit for Cs-137. This revision will benefit the entire country by providing that a larger number of sealed sources can be permanently disposed of, the safest and most secure method for their management.

5. Homogeneous/Similar Type Material:

   a. The NRC flowchart (CAE BTP Figure 1) outlines the new classification process, and shows the least scrutiny is given LLRW that is homogeneous and of similar type. Spent ion exchange resins at nuclear power plants certainly meet these criteria. As a result, generator States with nuclear power plants have a more streamlined process and will benefit more than other LLRW generators.

      Staff Response:

      The staff’s goal in revising the BTP has been to make it more risk-informed, performance-based, consistent with NRC’s regulatory philosophy. With respect to ion exchange resins, they were classified as homogeneous wastes in the 1995 BTP. As such, they were potentially subject to certain averaging constraints (the factor of 10 on inputs to a mixture of resins). At the same time, however, licensees could justify not using these constraints if operational efficiencies or worker dose reductions could be demonstrated from mixing of resins and other homogeneous wastes, and could thus streamline the classification of these wastes.

The staff also notes that other stakeholders will benefit from the changes to the BTP. For sealed sources, e.g., if Agreement States permit the use of the revised positions, this will help ensure national security and reduce the threat of a dirty bomb. The revised BTP has increased the allowable sizes for disposal of sealed sources.

6. Alternative Approaches:

   a. Alternative approaches off-ramp provided on NRC Figure 1, allows a generator to classify waste on the basis of the disposal site's performance assessment (PA) model analysis (also see CAE BTP pp. 20-23). This is a direct benefit to generators, in that provides an "off-ramp" for generators to avoid following the proposed classification criteria on NRC Figures 1 and 2. It also opens the door for variability in its application on a State-by-State basis.

      Staff Response:

      In a separate but related effort to the BTP, the Commission has directed the staff to develop a rule that would require a site-specific intruder assessment for LLRW disposal facilities. The BTP acknowledges that such approaches can currently be used to develop site-specific concentration averaging approaches. The principal reason for acknowledging that site-specific approaches can be used for averaging, based on a PA, is that this approach is performance-based, in that licensees do not necessarily have to use the generic averaging approaches in the BTP, but can achieve the objective of protecting an inadvertent intruder by another means, the site-specific performance assessment. With respect to variability, the BTP is not a rule and is therefore not subject to compatibility requirements for Agreement States. In fact, States have concentration averaging positions different from the existing BTP. In addition, many States argue for increased flexibility in adopting NRC criteria. As recently as the April 3, 2012, Organization of Agreement States and Conference of Radiation Control Program Directors meeting with the Commission, States have asked the Commission " . . . for your continued support of allowing States flexibility."

   b. Use of PA model analysis for alternative approaches has the potential to exploit an inherent disconnect between host States and generator States. If this "off-ramp" is used, host States will need to develop detailed Waste Acceptance Criteria (WAC) to ensure that generators properly prepare, package and ship their waste to be consistent with the specific intruder scenarios and waste form (physical/chemical) assumptions used in the approved PA model analysis for each disposal site. This could lead to extensive WAC guidelines that could vary from host State to host State, and waste class to waste class. This has the potential for additional burden on disposal States to communicate and educate generators and their regulators on how to comply with new WAC guidelines.

      Staff Response:

The staff acknowledges the concern. As noted above, the Commission has directed the staff to develop a rulemaking that would require site-specific intruder assessments to be performed by licensees. As with any new rule, States will have to invest resources in implementing the rule, including addressing stakeholder concerns raised during the States' rulemaking processes. The staff is willing to participate in public workshops to explain changes to the BTP in the sited States, consistent with available resources.

7. Enforceability Issue:

a. To a large degree the CAE BTP has the same flaw as the 1995 BTP guidance; in that separate regulatory jurisdictions govern different activities (generators vs. disposal), have different interests and motivations, and are separate and independent of one another. As such, generator States are more apt to worry about elimination and transfer of the waste from their jurisdiction, and pay less attention to disposal site considerations (e.g. design / site factors, PA analysis results, etc.). Because disposal States will live with the long-term fate and consequences of LLRW disposal, they are more likely to be concerned about adverse effects that waste treatment, classification, and packaging may have on their local environment and public health from the perspective of both near term and "deep time"; but are without legal jurisdiction or reach to oversee or enforce waste characterization/classification by the generator.

In addition, the CAE BTP (Figures 1 and 2) classification guidance for each waste container, is just that - guidance. There is no guarantee that it will be uniformly applied in all generator States. Utah will be dependent on each generator State agency to voluntarily implement the new guidance for each generator. NRC will not be able to compel the generator Agreement States to invoke the guidance. It is likely that there will be a high degree of variability on if, how and when, the new guidance is implemented in generator States. While the CAE BTP calls for generator States to cooperate with disposal State regulators (ibid., p, 4); there is no guarantee it will happen.

Staff Response:

A basic premise of the Atomic Energy Act Agreement State program is that each State will have a program that is adequate and compatible with NRC's regulations, ensuring protection of the public health and safety. NRC conducts periodic reviews of Agreement State programs to determine if they remain adequate and compatible. Thus, whatever different interests States might have regarding LLRW management cannot affect their responsibility to protect public health and safety. This responsibility includes ensuring that requirements relevant to intruder protection are appropriately implemented.

The staff disagrees in part that Utah will be dependent on generator Agreement States to implement the new guidance, since Utah has the authority to establish conditions for acceptance of waste at their regulated facility. Incoming waste must meet these requirements, even if the States in which the generators are located have different requirements for waste classification.

The staff understands that States with disposal facilities may want to have increased assurance and documentation that waste shipped from other States has been appropriately classified. As noted in response to comment no. 6.a from the State of

South Carolina, there are several possible approaches for increasing this assurance, such as the State of Washington's use of point-of-origin inspections. Additionally, the staff is willing to work with States on this issue.

b. It is true that the CAE BTP suggests that in the case of conflict between disposal site waste acceptance criteria (WAC)/License requirements and the generating State waste treatment process/requirements, that the disposal State requirements should prevail (ibid., p. 24). Unfortunately, this posture is unenforceable, in that the disposal State has no legal jurisdiction over the out-of-State generator, and cannot directly enforce its WAC/License requirements beyond its borders.

   Staff Response:

   The State can enforce its requirements for waste that has been shipped to the disposal site. In addition, the State of Utah has a Generator Site Access Permit program. That program requires that generator's permit applications include a certification to the State that the shipper shall comply with all applicable State or Federal laws, administrative rules and regulations, licenses, or license conditions of the land disposal facility regarding the packaging, transportation, storage, disposal and delivery of radioactive wastes. In addition, generators that ship waste must meet the manifesting requirements of 10 CFR § 20.2006, which references Appendix G, 10 CFR Part 20, "Requirements for Transfers of Low-Level Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests." Among many requirements in this Appendix are that generators must certify that material transported to the disposal site is properly classified.

   As noted in response to comment no. 6.a by the State of South Carolina, the staff is also willing to participate in discussions with the States on any discussions related to this issue with the goal of providing additional assurance to sited States that waste has been appropriately classified

c. The current EnergySolutions (ES) License requires ES to apply the existing 1983 and 1995 NRC guidance documents via the waste prohibitions in License Condition 16.L, that stipulate that ES not accept a package of LLRW unless it has been:

   "*i. Classified in accordance with R313-15-1009, "Classification and Characteristics of Low-Level Radioactive Waste." In addition, the Licensee shall require that all radioactive waste received for disposal meet the requirements specified in the Nuclear Regulatory Commission, "Branch Technical Position on Concentration Averaging and Encapsulation", as amended.*

   ii. Marked as either Class A Stable or Class A Unstable as defined in the most recent version of the "Low-Level Waste Licensing Branch Technical Position on Radioactive Waste Classification." originally issued May, 1983 by the U.S. Nuclear Regulatory Commission. …"

   From the first paragraph, the intent of the License is to indirectly mandate that generators properly package and classify the LLRW in accordance with the 1995 NRC BTP requirements. However well-meaning this requirement, it is currently un-inspectable; in that the Utah DRC (UDRC) has no authority in the generator States, nor are we easily able to independently verify if generators actually classify their waste as required. Instead UDRC is dependent on the generators to perform and the NRC or other Agreement States to confirm this. UDRC is without legal power or reach to independently verify if generators actually comply with the NRC classification guidelines.

Staff Response:

See response to previous question 6.a. The staff is aware of at least several methods that sited States can use to have reasonable assurance that waste is classified correctly. These include:

- The Washington Department of Health (DOH) began the Point-of-Origin Inspection Program in 1992. The goal of the program is to identify any deficiencies at generator facilities prior to waste being shipped for disposal. Identifying deficiencies before the waste is shipped will reduce subsequent packaging or waste form violations upon receipt at the commercial LLRW disposal site. DOH achieves this goal through random inspections of generator facilities. This program was used as a basis for a Model Inspection and Verification Program (DOE/LLRW-185) that was developed as guidance for other states.

- The Utah Department of Environmental Quality implements a Generator Site Access Permit program that provides additional assurance that generators have classified their waste appropriately. See Utah Radiation Control Rules R313-26.

- The U.S. Department of Energy (DOE) published a report, "Methods for Verifying Compliance with Low-Level Radioactive Waste Acceptance Criteria," (DOE/LLRW-185) that may also have useful information. This report was based on the Washington Department of Health generator inspection program.

The States regulate all of the LLRW disposal sites in the U.S., and as noted above, have implemented several requirements to obtain assurance that generators classify waste appropriately. The staff believes that the States, given their experience in implementing the BTP, are in a better position to address this issue, by for example, incorporating requirements into the disposal facility waste acceptance criteria. To the extent that the BTP can provide useful guidance on this topic, the staff is open to suggestions for specific language that might be added to the BTP.

d. There appears to be a conflict on performance of drums and encapsulation media. As mentioned above, the NRC requires Class B and C waste to be disposed in robust and stable containers, in that [10 CFR 61.7(b)(2)]:

> "*Those higher activity wastes that should be stable for proper disposal are classed as Class B and C waste. To the extent that it is practicable, <u>Class B and C waste forms or containers should be designed to be stable, i.e., maintain gross physical properties and identity, over 300 years</u>. For certain radionuclides prone to migration, a maximum disposal site inventory based on the characteristics of the disposal site may be established to limit potential exposure.*"

NRC has made clear that container integrity and waste form is key to controlling higher activity Class B and C waste, in that (1981 NRC DEIS, Vol. 1, p. 31)::

> "*The waste form (coupled with site design and operating practices) is probably the most significant factor contributing to site instability -- a factor containing the paradox that much if not most of the problems with site instability and high maintenance costs is caused by the wastes containing the least activity. Most of the waste sent to LLRW disposal facilities consists of very low activity material such as trash which is frequently easily degradable. In the past, some of this waste has been packaged in easily degradable packages such as cardboard boxes. Most of the waste, however, is currently packaged in longer lasting, but still degradable, rigid containers such as wooden boxes and 0.2 m^3 55-gallon steel drums. Large void spaces can also exist within waste packages and the disposal cells after waste disposal. As the waste material degrades and compresses, a process which is accelerated by contact by water, additional voids are produced. This leads to settlement of the disposal cell contents, followed by subsidence or slumping of the disposal cell cover. This increases the percolation of water into disposal cells, accelerating the cycle. This slumping and subsidence is frequently quite sudden.*" (emphasis added).
>
> Accordingly, the 1995 BTP assumed that steel drums corrode leaving only the encapsulation matrix to control the sealed source nuclides (1995 BTP, Appendix C, p. 22). As discussed above, the NRC staff appear to take a "deep time" point of view in the CAE BTP, and assume both the drum and encapsulation matrix degrade to become soil-like, leaving only the stainless steel cladded source behind to be "discovered" (CAE BTP, p. B-2). As discussed above, this view appears to be in direct conflict with those of the ACRS. This disagreement must be resolved before NRC moves forward to either a new rule or guidance on waste concentration averaging.

Staff Response:

The ACRS advises the Commission on a wide variety of issues, including the BTP. There is no requirement that the ACRS and staff agree on the provisions in the guidance. As noted in Appendix H, the staff does not agree with all of the ACRS recommendations at this time.

With respect to the apparent conflict noted by the commenter, NRC staff believes there is no actual conflict. NRC staff disagrees with the commenter's statement that NRC staff has taken a "deep time" point of view. The 1995 BTP and the 2011 draft revision to the BTP use 100, 300 and 500 year timeframes for performance of drums and encapsulating media, identical to those timeframes used in the 1981 DEIS and the 1982 FEIS for Part 61. The only significant difference is that the 1995 BTP and the 2011 draft revision of the BTP recognize and protect the inadvertent intruder from gamma hot spots in discrete wastes; whereas the DEIS and FEIS assumed all wastes to be radiologically homogeneous.

8. NRC/ACRS:

a. Evolution of NRC Intruder Scenario Assumptions: Sealed Source Disposal – the NRC intruder scenarios on the acceptability of sealed source disposal, and appropriate activity limits for sources at disposal have varied significantly over the past 30 years.

Recently the Advisory Committee on Reactor Safeguards (ACRS) recognized this and suggested NRC staff reconsider their approach by using "*…the same scenarios used to develop 10 CFR Part 61 without creating additional unrealistic scenarios to determine allowable concentrations or amounts of LLRW to be disposed.*" (12/13/11 ACRS letter, p. 2). This would indicate that the ACRS is encouraging the NRC to also reverse its 1995 BTP intruder scenario assumptions, which applied the 0.02 mR/hr contact dose limit to the steel drum (upon discovery/intrusion). If this is indeed their intent, then it would appear that NRC staff would need to revert to the intruder scenario described in the 1982 FEIS.

The ACRS also stated that the CAE BTP sealed source intruder scenario was overly conservative, did not recognize the depth of burial, and that the "carry-away" scenario had already been ruled unlikely in the Final EIS. Further, they concluded that the most appropriate scenario for sealed source disposal was the "discovery-scenario" in the 1982 Final EIS (12/13/11 ACRS letter, p. 3-4); which is actually an abbreviated version of the dwelling construction scenario in the 1982 FEIS (Vol. 1, p. 4-14). The "discovery scenario" assumes the drum and encapsulation media remain intact; thus denying the possibility of a habitation/agricultural scenario that may be more applicable under "deep time" considerations.

The ACRS also went on to say: *"…the use of overly conservative scenarios "for inadvertent intrusion into presumably abandoned, unmarked, and unsecured LLRW disposal facilities can change the focus of the facility design from the protection of the health and safety of the public during the period of operation of the facility (and a reasonable period thereafter), to the protection of hypothetical intruders many thousands of years in the future."* Unfortunately, the ACRS provided no definition of what it considered a "reasonable period" after disposal.

At the root of the discussion, it appears the ACRS prefers NRC use a short period of performance, in that they envision the drum and encapsulation matrix is intact, allowing the intruder to easily recognize the waste form is artificial, and prevent exposure. In contrast, NRC staff appears to view the problem in terms of "deep time", and acknowledge the shortcomings in the 1981 DEIS, 1982 FEIS in that the 10 CFR classification system is flawed, as follows:

- <u>Short Lived Waste Assumption</u> – that LLRW will experience significant decay in 100 (Class A), 300 (Class B), and 500 years (Class C) after disposal. Unfortunately, the current NRC rule fails to acknowledge long-lived isotopes, known to exist in LLRW and power plant wastes, e.g., Tc-99 (half-live = 211,000 years), that will not significantly decay in 500 years or less.
- <u>Opposite Behavior of Depleted Uranium</u> – where long term ingrowth of decay products increase the risk to the public. This was the mission the NRC staff were charged with by the Commission, as a means to reconcile the Louisiana Energy Services lawsuit.

So a disparity exists between the NRC staff and the ACRS, that is critical to reconcile before any final NRC rule is revised, adopted, and final guidance issued. From the ACRS letter, it appears the advisory group prefers a shorter 1,000 year period of performance (POP), as is the case with current DOE policy for waste disposal. In contrast, longer time periods are being considered by NRC staff in response to SECY-08-0147.

Staff Response:

This comment contains multiple comments, and each comment is repeated below with a response.

Comment - "This would indicate that the ACRS is encouraging the NRC to also reverse its 1995 BTP intruder scenario assumptions, which applied the 0.02 mR/hr [note—should be 0.02 μSv/yr (0.02 mrem/hr)] contact dose limit to the steel drum (upon discovery/intrusion). If this is indeed their intent, then it would appear that NRC staff would need to revert to the intruder scenario described in the 1982 FEIS."

Staff Response – The full ACRS statement is that:

> "<u>If the staff believes</u> that 10 CFR Part 61 constrains the use of a more risk-informed, performance-based treatment of intruder scenarios, then we recommend using the same scenarios used to develop 10 CFR Part 61 without creating additional unrealistic scenarios to determine allowable concentrations or amounts of LLRW to be disposed." (emphasis added)

The staff, consistent with the 1995 BTP, has used a new scenario, different from the DEIS scenarios, for restricting the activity of sealed sources and other small items. The staff will seek stakeholder views on this approach in soliciting public comments, and will identify the ACRS concerns for public consideration and comment.

Comment - "The ACRS also stated that the CAE BTP sealed source intruder scenario was overly conservative, did not recognize the depth of burial, and that the "carry-away" scenario had already been ruled unlikely in the Final EIS."

Staff Response – Staff does not believe that the sealed source intruder scenario presented in the 2011 draft revised BTP is overly conservative, and as evidence, staff notes that the use of the new 2011 scenario results in *an incremental increase in the allowable curie limit* for Class C disposal of Cs-137 gamma sources (from 1.1 TBQ (30 Ci) to 4.8 TBq (130 Ci)). The staff will highlight the ACRS views in soliciting public comments, however, and revisit the appropriateness of this scenario in developing the final BTP.

Comment - "… it appears the ACRS prefers NRC use a short period of performance… In contrast, NRC staff appears to view the problem in terms of "deep time" …"

Staff Response – Staff agrees with ACRS that a shorter period of performance is appropriate. In the 1995 BTP and in the August 2011 draft revision to the BTP, NRC staff used 100, 300 and 500 year timeframes, identical to those timeframes used in the 1981 DEIS and the 1982 FEIS for Part 61, to ensure that intruder doses are within acceptable limits, consistent with the technical bases for the waste classification tables in 10 CFR § 61.55.

Comment - "…Opposite Behavior of Depleted Uranium …From the ACRS letter, it appears the advisory group prefers a shorter 1,000 year period of performance …"

Staff Response – The BTP does not specifically address disposal of depleted uranium. Concentration averaging is not a significant issue in the disposal of depleted uranium tails from enrichment plants.

Although the staff and ACRS agreed on a number of issues, as noted earlier, there is no requirement that the ACRS and the staff agree on all issues. The ACRS provides its views to the Commission, as an organization independent from the NRC staff.

9. Waste Acceptance Criteria (WAC):

   a. Not all disposal sites have detailed WAC to constrain waste physical and chemical form, leachability, etc., before land disposal.

      Staff Response:

      Agreement States can specify appropriate requirements for the waste characteristics in either a waste acceptance criteria document, typically developed by the licensee, or in the disposal facility license.

   b. The proposed guidance relies on disposal site WAC's (founded on site-specific PA analysis) to guide generators in the waste classification process. This added complexity for generators (and their regulators) could lead to increased errors in waste preparation, packaging, and classification for disposal.

      Staff Response:

      NRC staff and stakeholders found the existing 1995 BTP to be difficult to understand and the staff has improved its clarity which should reduce errors and misinterpretations. That said, site-specific WAC's can implement all, or none, or part of the BTP. For example, if a site-specific assessment demonstrates that some of the BTP's underlying intruder scenarios are highly unlikely, the associated averaging constraints may not be needed.

      In any case, generators need to take steps necessary to ensure that preparation, packaging, and classification are performed in accordance with the WAC. They may be subject to enforcement action if they did not meet the waste acceptance criteria.

   c. When disposal states lack legal reach on generators, such errors can increase potential jeopardy for disposal state public health and environment.

Staff Response:

As noted in response to an earlier comment (No. 6.a from the State of South Carolina), a basic premise of the Atomic Energy Act Agreement State program is that each State will have a program that is adequate and compatible with NRC's regulations, and that will ensure protection of the public health and safety. NRC conducts periodic reviews of Agreement State programs to determine if they remain adequate and compatible.

In addition, Utah has the authority to establish conditions for acceptance of waste at the Clive facility. These requirements must be met by generators from other States that ship waste for disposal, even if the States in which the generators are located have different requirements for waste classification.

The staff understands that States with disposal facilities may want to have increased assurance and documentation that waste shipped from other States has been appropriately classified. As noted in response to South Carolina comment 6.a, there are several possible approaches for increasing this assurance, such as the State of Washington Point-of-Origin inspections. The staff is willing to work with States on this issue.

d. Disposal states should have the ability to promulgate rules that are more stringent than NRC to protect their public health and environment.

Staff Response:

NRC has various categories of compatibility that are defined in an internal procedure "*Compatibility Categories and Health and Safety Identification for NRC Regulations and Other Program Elements* - SA-200" (ADAMS Accession No. ML042820600). The compatibility of rule provisions can range from essentially identical requirements with the NRC rule, to no compatibility requirements. The NRC coordinates with States in the development of rules, including the assignment of compatibility categories. The BTP is NRC guidance and is not subject to compatibility requirements.

e. In deciding compatibility categories for new rules, NRC must provide flexibility in order to allow disposal states to afford this protection to its citizens.

Staff Response:

As noted above, NRC's has a detailed procedure for assigning compatibility categories. Some flexibility is afforded to the States, depending upon the specific rule provision. See NRC's internal procedure SA-200 (ADAMS Accession No. ML042820600).

10. Agreement State Compatibility Categories:

a. Disposal states should have the ability to promulgate rules that are more stringent than NRC to protect their public health and environment.

Staff Response:

See response to 9.d above.

b. In deciding compatibility categories for new rules, NRC must provide flexibility in order to allow disposal states to afford this protection to its citizens.

Staff Response:

See response to 9.e above.

11. Action Items:

a. Guidance alone is not sufficient to ensure that long-term public health and the environment will be protected in the disposal States; especially under “deep time” conditions. Therefore, after NRC promulgates new federal rules regarding LLRW blending and DU disposal, etc., the agency will need to define compatibility categories for purposes of IMPEP. This is critical for at least two reasons:

- Generator State Implementation – the compatibility category assigned to the new rule(s) must be substantial so as to mandate the generator State implement equivalent rules on how LLRW is to be classified before shipment for disposal. This is important for trans-boundary reasons. However, if the NRC assigns an insignificant compatibility category (e.g., Category D) the purpose of the new rule would be defeated from the disposal States' viewpoint. As a result, in assigning a compatibility category NRC must seek out and resolve disposal State input.
- Disposal State Flexibility – in assigning a compatibility category for the new rule(s), the NRC must allow disposal States flexibility to establish LLRW disposal rules that are not only equal, but also more protective of public health and the environment than minimum requirements set by the NRC. Failure to allow this flexibility, would relegate disposal States to a lower degree of standing than generator States, and further exacerbate the imbalance between disposal State long-term protection of public health and the environment in lieu of short term needs of generator States who enjoy the benefits of modern technology; but have chosen not to host a LLRW disposal site.

Staff Response:

The staff notes the comment, which is not directly related to the BTP, but to an ongoing rulemaking addressing disposal of depleted uranium and other issues. As part of its rulemaking process, NRC coordinates extensively with Agreement States, including the States with disposal sites. As noted above, NRC's compatibility criteria are defined in Office of Federal and State Materials and Environmental Management Programs procedure SA-200 (ADAMS Accession No. ML042820600) and is part of the NRC's rulemaking process.

b. In light of the January 19, 2012 NRC Staff Requirements Memorandum, where the Commission directed the NRC staff to re-evaluate its approach to the proposed limited rulemaking at 10 CFR 61 (and guidance), it is clear that the compatibility determinations will need to be revisited (see 9/30/11 NRC letter, Enclosure 1, p. 54). Utah and other sited states will need to reserve an opportunity to re-assess the proposed compatibility categories, until after the revised NRC staff position/rules are provided.

Staff Response:

The staff acknowledges the comment which concerns an ongoing rulemaking.

<u>Texas Commission on Environmental Quality Comments</u>

1. General:

a. The draft BTP, although guidance, could be the precursor to rulemaking in many areas.

Staff Response:

The staff has no intention or plans to implement a rulemaking to incorporate the provisions in the BTP into the rules, with one exception. The revised BTP addresses site-specific intruder assessments in the alternative approaches section, the topic of an ongoing rulemaking.

b. Although the draft BTP adds a sentence in the introduction in response to comment that it is expected that Agreement States that regulate processing and those that regulate disposal "would consult one another," this is the only reference to how this will be applied across the States. Without NRC leading the way to foster this cooperative approach, the statement falls short of having any impact. There is a disconnect between the regulation and inspection at the point of waste generation/processing and the implications for the regulation at the disposal sites. A passive approach to coordination will leave a disconnect related to classification of waste and regulation of that waste from the handling/processing licensee to the disposal licensee.

Staff Response:

The staff is willing to discuss approaches for ensuring that regulatory agencies appropriately coordinate in ensuring that waste is classified appropriately. As noted in response to the State of South Carolina's comment No. 6.a, Agreement States have implemented programs for better ensuring that waste that is received by disposal facilities is appropriately classified. The staff also notes that this issue has not been created by the revisions to the BTP, but is an issue that existed previous to the NRC's revision of the BTP.

c. It is difficult to foresee impacts of making changes at this critical time in just approaching opening of the commercial Texas disposal facility. There are both practical and perception issues for the possible implementation of provisions of this draft guidance. The draft BTP should include more discussion of possible impacts other than those identified in the inadvertent intruder scenarios to provide other consideration for implementation of provisions.

Staff Response:

The staff believes the commenter is referring to more general impacts in LLRW disposal, rather than impacts of the revised BTP on intruder protection. Similar broad concerns were raised by stakeholders during the staff's outreach on LLRW blending. These concerns were discussed by the staff for consideration by the Commission in SECY-10-0043, "Blending of Low-Level Radioactive Waste," Section 3.1.3, "Impact on Existing LLRW Management Program." That section identifies potential non-safety impacts on the new Texas LLRW disposal facility, such as its economic viability and its receipt of less Class B/C waste stream volumes. In the SECY, the staff noted that it did not independently analyze these potential impacts, since NRC's responsibilities as a regulatory agency are limited to ensuring protection of the public health and safety and the environment and promoting the common defense and security. The Commission decided to implement a risk-informed, performance-based position on blending that included revisions to the BTP, after consideration of all of the issues associated with LLRW blending, including these broader non-safety impacts on the Texas facility.

Notwithstanding the above, the BTP is NRC guidance and Agreement States are not required to use the revised BTP, and if they do, there is no timetable for doing so. The staff believes that the proposed revisions are more risk-informed and performance-based and will have beneficial impacts on disposal of LLRW. Sealed source disposal will be facilitated resulting in enhanced national security, for example.

2. Blending:

a. Texas has a rule in place against reclassification of waste due to the intentional mixing for any purpose. When the Texas rule was put in place decades ago, there was no distinction between dilution and blending. With BTP as guidance and in discussions with NRC staff, it is assumed that the state's compatibility with blending approaches will have little to no effect on this Texas policy.

Staff Response:

NRC found the Texas rule to be compatible with NRC regulations. The new site-specific analysis rulemaking for 10 CFR Part 61 will require a site-specific intruder assessment, including an assessment for blended waste. The compatibility category is yet to be determined, and Agreement States will have an opportunity to provide their views on the appropriate category.

b. A related issue in the blending discussion is the attribution of waste generator to a processor. This is a possible side-effect of blending that is problematic for disposal States. There are State requirements for identification and record-keeping of each original waste generator. The possible attribution to another entity at any point in the waste processing cycle complicates the disposal State fulfilling its responsibility for identification of waste generator.

   Staff Response:

   NRC regulations address attribution of waste in 10 CFR Part 20, Appendix G, "Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests." Specifically, Appendix G defines the term, "residual waste" as "LLRW resulting from processing or decontamination activities that cannot be easily separated into distinct batches attributable to specific waste generators. This waste is attributable to the processor or decontamination facility, as applicable." The NRC requirements for attribution, which are based on health and safety considerations, do not always satisfy the needs of the sited States and Compacts who may want to know the origin of waste. The staff understands that States with operating disposal facilities have been able to obtain the additional information on the origin of waste from waste processors. This issue was addressed in the staff's paper on LLRW blending, SECY-10-0043.

c. The footnote on blending for avoiding extreme measures to lower waste classification misses the mark of providing necessary guidance that should be considered by NRC. The footnote was added in response to comment but does not provide guidance as to how this might be identified and implemented.

   Staff Response:

   The footnote has been revised somewhat and moved to Table C, "Volume and Mass for Determination of Concentration." With respect to blending, the Commission decided in its Staff Requirements Memorandum for SECY-10-0043, "Blending of Low-Level Radioactive Waste," to risk-inform, performance-base the agency's blending position. In practice, that means that mixable wastes can be blended, including those that have Class B or C concentrations with waste of Class A concentrations to form a Class A final mixture. Waste is not required in NRC's regulations to be classified until it is shipped for disposal. Therefore, these wastes do not have their waste classification lowered, as they are not classified at the time of mixing. This revision to the BTP provides new guidance for this recent Commission decision.

   Although blending is permissible, the footnote is intended to address the addition of non-radioactive materials to LLRW. These materials could be used for waste stabilization or process control, for example. In other NRC guidance on mixing of non-radioactive materials with waste, the staff has used language similar to that provided in this revised BTP, and has not provided detailed, prescriptive criteria. The staff is open to stakeholder suggestions on additional, more detailed guidance, however.

3. Increase in Sealed Source Activity:

a. It is unknown what the implications of the significant increases for sealed source disposal will be in Texas. The pressure for Texas to open up sealed source disposal to allow for these increases specifically on at the commercial disposal facility owned by the State of Texas, as well as alternative disposal of even larger sources, is already evident. It is difficult to make such a shift to increase sealed source disposal at this critical time in just approaching opening of the Texas disposal facility, with the immediate consideration and review of intrusion scenarios that are less restrictive then currently considered.

   Staff Response:

   The BTP is NRC guidance and States can choose to recognize it or not, and if so, can do so on their own schedule. The staff believes that the increases in recommended limits for sealed sources are incremental rather than significant. The staff appreciates that Texas is addressing licensing issues associated with the opening of the facility and that addressing the BTP may not be an immediate priority.

b. It appears the focus is on changes for larger commercial sealed source disposal in sited states. The scope of this issue should not solely focus on the back-end disposal remedy for sealed sources. If front-end issues are not also addressed in recognition of their impact to future available options, the problem will not be solved.

   Staff Response:

   The Federal government has other initiatives to address front end issues associated with sealed sources, such as financial assurance for disposal of the disused sources. The *Energy Policy Act of 2005* directed the Radiation Source Protection and Security Task Force, to evaluate and provide recommendations relating to the security of radiation sources in the United States from potential terrorist threats, including acts of sabotage, theft, or use of a radiation source in a radiological dispersal device. The task force is comprised of independent experts from 14 Federal agencies and two State organizations, the Conference of Radiation Control Program Directors and Organization of Agreement States, and is chaired by the NRC. The independent task force members represent agencies with broad authority over all aspects of radioactive source control, including regulatory, security, intelligence, and international activities. The Task Force report addresses improvements in source tracking, licensing, transportation and import/export, along with disposal.

   The Task Force published a 257 page report in August 2006 (ADAMS Accession No. ML062440453) with numerous findings and recommendations, and updated the report in August 2010 (ADAMS Accession No. ML101890508). At an October 19, 2011, meeting in Santa Fe, New Mexico, the NRC staff briefed the LLRW Forum's Disused Source Working Group, including members from the sited States, on how front end sealed source issues are being addressed..

The staff agrees that front-end issues are important, but believes they are being appropriately addressed.

c. Also in regard to sealed sources, it seems prudent for NRC to address the intentional destruction of sealed sources in order to meet the blending definition and requirements.

Staff Response:

The blending position in the BTP, which was adopted by the Commission in its Staff Requirements Memorandum for SECY-10-0043, "Blending of Low-Level Radioactive Waste" (NRC 2010), addresses the physical mixing of similar waste streams, such as ion exchange resins. Sealed sources were not addressed as a component for blending in the SECY, and the NRC is not endorsing or addressing the destruction of sealed sources in the BTP. The staff will consider the commenter's recommendation, in developing the final version of the BTP, however, and after receiving stakeholder comments on this practice.

It should be noted that a special Focus Group, created by the Department of Homeland Security Nuclear Government Coordinating Council and Nuclear Sector Coordinating Council on the Removal and Disposal of Disused Sources, published a report on June 30, 2010, entitled "Sealed Source Disposal and National Security: Recommendations and Messaging Strategy." (DHS 2010) The report recommended that NRC and the Agreement States consider expanded physical destruction of sources. Currently, some licenses are engaging in physical destruction of sources on a very limited basis, according to the report. The staff is seeking additional views on this issue from stakeholders during the public comment period for the May 2012 revised draft, given the recommendation in the above report.

4. Absorbed Liquids:

a. The Texas license does not specifically prohibit absorbed liquids, although it is a topic of ongoing discussion. Since Texas might be alone in allowing absorbed liquids into a low-level disposal facilities (with other sites currently prohibiting), there should be some discussion of how long sorption can be relied upon in NRC analysis in the draft BTP where the possible presence of free-liquids in the future could impact the analysis. There is little information available to the sited states on this subject, other than the institutional memories of having problems in the past operational experience that are assumed to have lead to prohibitions on absorbed liquids.

Staff Response:

In the August 2011 revised draft of the BTP, the staff allowed for the averaging of absorbed liquids over the volume of the final waste form (i.e., liquid plus absorbent). The rationale for this change was that absorbed liquids are a homogeneous waste form, and even if liquids did not remain absorbed after disposal, they would be absorbed in soil, and mixed with soil as a result of human intrusion. Thus, there is no intruder safety concern with allowing this more liberal approach to averaging of absorbed liquids. In meetings with the States, however, they pointed out that free liquids can be problematic for waste that is received at disposal facilities, in that the waste acceptance criteria places a limit on them. In addition, it is possible that free liquids might adversely affect containment of radionuclides during disposal and facilitate their release into groundwater and compliance with 10 CFR § 61.41. For these reasons, the staff has revised the BTP to state, as in the 1995 BTP, that absorbed liquid radioactivity concentrations should be measured over the volume of the original liquid, not the final volume consisting of liquid and absorbent.

5. Factor of 10:

   a. Hot spot detection could be difficult to practically accomplish in many cases. This provides another disconnect between the regulation and inspection at the point of waste generation/processing and the implications for the regulation at the disposal sites. This might be an area that the disposal states would want to keep the factor of 10 (as Barnwell has in its license). What are the implications for sited states in taking this approach as far as the differences between the draft BTP and say using the Rule of 10 at Barnwell? Knowing the practical implications for Class B & C waste disposal is important for the policy considerations for possible implementation of this change for the high-end Class B & C waste nationwide.

      Staff Response:

      One of the purposes of the BTP is to limit hot spots in waste that could potentially affect protection of an inadvertent intruder. In the context of the comment (i.e., the comment is made by Texas, a State with a disposal facility), hot spot detection is a potential issue for waste that is received at a disposal facility. Waste is normally not removed from packaging, and so hot spots must be detected through radiation surveys. The staff has addressed how sited States might gain assurance that waste is appropriately classified in response to Comment 6.a.

      With respect to the State of South Carolina Barnwell rule of 10, the staff does not believe that it affects hot spot detection at the disposal facility. The Barnwell rule of 10 is defined in part as "Individual components exceeding Class C concentration limits can be averaged with components that are less than Class C concentration limits provided that their 10 CFR, Part 61, Table I and Table II sum of the fractions do not differ by more than a factor of 10." There are other provisions for the rule of 10, but all appear to be aimed at limiting the variability in concentrations of components that are packaged together.

      With respect to the differences between the revised draft BTP and the Barnwell rule of 10, the draft BTP contains the Factor of 2 and Factor of 10 constraints on averaging, which apply to gamma emitters and non-gamma emitters respectively. The factor of 2, for example, states that if primary gamma emitters control the classification of a mixture of items, no item in the mixture should have a classification controlling radionuclide concentration more than two times the classification limit for the mixture. The purpose of this factor is to limit the degree of hot spots by tying them to the class limit. The purpose of the Barnwell rule of 10 appears to be to limit the degree of hot spots and provide for more uniformity in the mixture.

The staff has not undertaken a comparison of how Class B and C waste disposal would be affected by the Barnwell rule of 10, since the revised BTP has not adopted that criterion. The revised draft of the BTP is intended to make the 1995 BTP more risk-informed, performance-based. In this regard, the previous averaging constraints for mixtures of items, the factors of 1.5 and 10, have been adjusted to be better tied to risk. Specifically, the new factors of 2 and 10 are tied to the class limit, not the average of the mixture. The previous factors ensured uniformity of the mixture, but uniformity is not related to intruder risk. The new limits are tied to the class limit, which is based on intruder risk. The State of South Carolina has indicated in its February 17, 2012, comments on the revised draft of the BTP that the changes to the BTP are expected to have a minimal effect on disposal of hardware compared to continued adherence to the Barnwell Rule of 10.

6. Alternative Approaches:

   a. Although NRC has opened up these alternative options in the revised BTP, it does not address the underlying reasons why sited States have not taken these considerations up to this point. By less reliance on standard acceptance criteria approved by sited State regulators, there is a level of confidence given to the abilities and resources available to every waste generator/processor shipping for disposal. For sited States, these are licensed entities which they largely do not regulate nor have impact over waste handling and classification decisions.

   Staff Response:

   The staff appreciates the sited States' desire to have assurance that waste shipped for disposal is appropriately classified. Potential methods for gaining assurance are addressed in response to comment 6.a from the State of South Carolina. At the same time, other approaches for averaging can provide for safe disposal of wastes that would otherwise have to be stored, including sealed sources that potentially pose a national security threat. One of NRC's goals in revising the BTP is to make it more performance-based, i.e., to allow for a variety of approaches that achieve one of the desired outcomes, the protection of an inadvertent intruder.

7. Regulation by Disposal States:

   a. For disposal States, waste for disposal comes from generators/processors that they do not regulate nor have impact over waste handling and classification decisions. Other State regulators and the NRC who do have authority over generators/processors, have different regulatory emphasis than the sited States and are independent. Even if it is assumed that the NRC-prescribed consultation occurs among regulators on each decision, there are inherent drivers that will always impact how disposal concerns from disposal States regulators are considered and potentially acted upon.

Staff Response:

As noted in an earlier response to a comment, a basic premise of the Atomic Energy Act Agreement State program is that each State will have a program that is adequate and compatible with NRC's regulations, ensuring protection of the public health and safety. NRC's policy on adequacy and compatibility also provides for flexibility in Agreement State program implementation to accommodate individual State preferences, State legislative direction, and local needs and conditions. NRC conducts periodic reviews of Agreement State programs to determine if Agreement State programs remain adequate and compatible. Thus, whatever different interests and regulatory emphasis NRC and other States might have regarding LLRW management cannot affect their responsibility to protect public health and safety.

The staff understands that States with disposal facilities may want to have increased assurance and documentation that waste shipped from other States has been appropriately classified. As noted in response to Comment 6.a from the State of South Carolina, there are several possible approaches for increasing this assurance, such as the State of Washington point-of-origin inspections. Additionally, the staff is willing to work with States on this issue.

b. Although the NRC guidance in the revised BTP is primarily designed for generators, who are required to certify that they meet the Class A, B, or C waste classifications in Part 61, it should be noted that the sited States may be burdened with increased costs to ensure compliance.

Staff Response:

Although some of the specific constraints on averaging have changed for various waste types, the number of constraints is approximately the same in the 1995 and May 2012 versions of the BTP. Thus, a State's review of concentration averaging and waste classification by generators to ensure compliance with license conditions related to these topics should be similar for the existing and revised BTP. Only the Alternative Approaches section is new and could be used by licensees to request regulators to approve other methods of averaging.

8. Recommendations for Consideration:

a. There should be a more focused public outreach in each of the disposal states, in order to discuss the practical implications of the changes and possible waste disposal alternatives to be considered. The NRC could hold public meetings in each of the disposal states and should use the sited state interested party notification lists to alert the public and other stakeholders.

Staff Response:

The staff will participate in meetings in the sited States to discuss the final version of the revised BTP, if requested by the States and subject to available resources. The staff can describe changes to the 1995 version, the reasons for them, the variety of views received from stakeholders, and benefits of the changes, such as increased disposal options for sources if the CA BTP is used by the States. With respect to the interested party notification, the staff will work with the States if a public meeting is requested to ensure that as many of the potentially interested stakeholders are notified of a meeting as possible.

b. The draft BTP should discuss and support independent or joint point-of-origin inspections of waste processors by the sited States. The NRC should sponsor BTP regulatory oversight training classes for sited State personnel and for States with waste processors. The NRC should include sited State personnel as IMPEP team members for audits of states with waste processors.

Staff Response:

The purpose of the BTP is not to prescribe inspection and oversight procedures, which are designed to ensure that regulations and guidance are being appropriately implemented. The BTP is a guidance document to assist both regulators and regulated entities with waste classification. Given the States' interest in obtaining additional assurance that the BTP provisions are being appropriately implemented, however, the staff is willing to participate in training classes. As noted in earlier comment responses (Comment 6.a from the State of South Carolina), there are a variety of methods that sited States could use to increase oversight, and more focused discussion among the sited States is probably warranted. The staff is also willing to participate in these discussions.

With respect to IMPEP reviews, FSME Procedure SA-120, "*Agreement State Participation as IMPEP Team Members*" contains specific guidance on Agreement State participants in IMPEP. IMPEP frequently uses Agreement State technical expertise in LLRW as part of the team.

<u>LLRW Forum Disused Source Working Group Comments</u> (Comments that were already addressed above in sited States' letters are not included here)

1. Increase in Sealed Source Activity:

   a. Sited State stakeholders could challenge the significant increase in the sealed-source activity limits, which are based on a new intrusion scenario that is less restrictive.

      Staff Response:

      While, in some cases, the resulting disposal limits are incrementally less stringent than the 1995 BTP (see response to Comment No.1 from the Utah Division of Radiation Control on the increase in sealed source activity), the NRC staff believes the changes in the BTP are defensible.

   b. Since there are a limited number of Cs sources, a more prudent approach may be to encapsulate and store for decay to a much lower activity than 1.1 TBq (130 Ci).

Staff Response:

Based on analysis presented in Appendix B to the 2011 draft revised BTP, staff believes that 4.8 TBq (130 Ci) Cs-137 sealed sources can be safely encapsulated and disposed in a Class C disposal facility. The staff believes that prompt disposal of a 4.8 TBq (130 Ci) Cs-137 source would be safer than storage of it for 60 years and subsequent disposal as a 1.1 TBq (30 Ci) source. Sixty years is the time required for Cs-137 to decay from 4.8 TBq (130 Ci) to 1.1 TBq (30 Ci). Long-term storage would cause worker exposures from inspections of waste, and have a higher risk for the material to be stolen or abandoned.

c. The BTP should clearly make a statement against the destruction of sealed sources in order to meet the blending definition and requirements.

Staff Response:

The staff will consider this recommendation but believes it is premature to take this position in the BTP on this waste management technique. The Department of Homeland Security Nuclear Government Coordinating Council and Nuclear Sector Coordinating Council on the Removal and Disposal of Disused Sources published a report on June 30, 2010, entitled "Sealed Source Disposal and National Security: Recommendations and Messaging Strategy." The report recommended that NRC and the Agreement States consider expanded physical destruction of sources. The staff is seeking additional views on this issue from stakeholders on this technique, especially in the context of concentration averaging, given the recommendations in the above report.

2. Factor of 10:

a. Factor of 10 in determining waste homogeneity (hot spots should not be greater than 10 times the class limit in determining homogeneity) is different than Factor of 10 for classifying hardware and other types of waste. It appears as though TX and WA comments are about hot spots and the SC comment is about hardware classification. [NRC staff note--this comment was identified as belonging to South Carolina, but was not included in the State's separate comment letter].

Staff Response:

The Barnwell rule of 10 applies to gamma and non-gamma emitters and is linked to the average concentration of the mixture, based on the sum of fractions. The draft BTP contains the factor of 2 and factor of 10 constraints on averaging, individual classification-controlling nuclides that apply to gamma emitters and non-gamma emitters respectively. The factor of 2, for example, states that if primary gamma emitters control the classification of a mixture of items, no item in the mixture should have a classification-controlling radionuclide concentration more than two times the classification limit for that nuclide. The purpose of this factor is to limit the degree of hot spots by tying them to the class limit. The purpose of the Barnwell rule of 10 appears to be to limit the degree of hot spots and provide for more uniformity in the mixture.

3. Performance Assessment:

   a. Sited State stakeholders could challenge the new performance assessment's (PA) generic exposure scenarios for being too conservative or not conservative enough.

      Staff Response:

      The staff acknowledges the comment. The staff has received substantial input from stakeholders with a wide variety of views, and carefully considered each comment. Some, such as the Advisory Committee on Reactor Safeguards, have advocated for less stringent provisions than the staff has adopted in the revised draft BTP. The staff does not expect to eliminate every stakeholder concern, but is committed to documenting how each stakeholder comment has been addressed and how protection of public health and safety is being maintained.

   b. Since it references the proposed site-specific analysis rulemaking, sited States may need to redo their PAs, using the scenarios described in the BTP.

      Staff Response:

      Comment noted. Disposal facility licensees would be required to perform a site-specific intruder assessment when the ongoing 10 CFR Part 61 rulemaking is completed. The BTP's reference to this rulemaking would not require a redo of a licensee's PA, since the BTP is guidance.

      The scenarios used in the BTP are generic, and specific sites may have to use different scenarios, based on the site design and location, to perform the assessments that are expected to be required by the ongoing site-specific analysis rulemaking.

4. Alternative Approaches:

   a. Sited State stakeholders could challenge the use of the alternative approaches position as a way to circumvent the BTP and requirements found in § 61.58.

      Staff Response:

      The BTP is guidance and not a regulation. NRC guidance such as the BTP provides one method by which licensees may demonstrate compliance with NRC's regulations. The alternative approaches section allows for site- and waste-specific approaches to concentration averaging that will also ensure protection of public health and safety. Alternative approaches, as noted in the BTP, would need to be approved by the appropriate regulator. 10 CFR § 61.58, on the other hand, is not designed to be used to approve licensee approaches different from those in NRC *guidance.* It is to be used for alternatives to the waste classification *requirements* in 10 CFR 61.

   b. Removes NRC responsibility for reviewing some BTP alternative approach proposals and places the responsibility and cost for review and approval on the sited States.

Staff Response:

Review of “alternative approaches,” whether they be under 10 CFR § 61.58 as the 1995 BTP prescribes, or under the new Section 4.9 of the BTP, is the responsibility of the regulatory authority for the disposal facility, as noted in both the 1995 BTP and revised draft. NRC staff has not shifted any responsibilities to the States for these reviews.

c. What specific requirements will the NRC place on sited States that choose to use the BTP alternative approach that is exempted from § 61.58?

   Staff Response:

   Deviations from the waste classification requirements in 10 CFR Part 61 can be approved by the regulatory authority, either under 10 CFR § 61.58 if being approved by NRC, or a compatible provision in State regulations if being approved by an Agreement State. Deviations from the guidance in the body of the BTP (that are within the scope of 10 CFR 61 requirements) can also be approved by the regulatory authority. The guidance in the alternative approaches section would inform those reviews. NRC has no specific requirements on sited States that wish to use the alternative approaches guidance.

5. Enforceability Issue:

   a. Although the NRC guidance in the revised BTP is primarily designed for generators, who are required to certify that they meet the Class A, B, or C waste classifications in Part 61, it should be noted that the sited States may be burdened with increased costs to ensure compliance.

      Staff Response:

      Although the specific constraints on averaging have changed for various waste types, the number of constraints is approximately the same and all would require review to ensure compliance. States currently review waste classification by generators to ensure compliance with the applicable regulations and license conditions. Only the Alternative Approaches section is new and could be used by licensees to request regulators to approve other methods of averaging.

6. Waste Acceptance Criteria (WAC):

   a. The NRC should sponsor BTP regulatory oversight training classes for sited State personnel and for States with waste processors.

      Staff Response:

      The staff will, upon request, and subject to available resources, meet with State regulators to provide an overview and training on the changes to the BTP.

b. The NRC should consider adding a new non-common indicator to the Integrated Materials Performance Evaluation Program (IMPEP) for the revised BTP.

   Staff Response:

   The staff does not believe that the BTP warrants the status as a non-common performance indicator in the IMPEP program. IMPEP indicators are for large programmatic areas such as low-level waste disposal and uranium recovery. The BTP is a single guidance document covering a limited aspect of the overall LLRW management and disposal program. Implementation of the BTP could be selected for review of an Agreement State program by the IMPEP team.

c. The BTP should discuss and support independent or joint point-of-origin inspections of waste processors by the sited States.

   Staff Response:

   See response to State of South Carolina Comment 6.a.

d. There should be a more focused public outreach in each of the sited States, in order to discuss the practical implications of the changes and possible waste disposal alternatives to be considered.

   Staff Response:

   The staff will participate in public meetings upon request of the sited States, consistent with available resources.

References:

Department of Homeland Security, Nuclear Government Coordinating Council and Nuclear Sector Coordinating Council on the Removal and Disposal of Disused Sources, "Sealed Source Disposal and National Security: Recommendations and Messaging Strategy. June 30, 2010

EPA, 1985, *Federal Register*, Vol. 50, No. 182, page 38088.

NRC, Staff Requirements Memorandum — SECY-10-0043,"Blending of Low-Level Radioactive Waste." October 13, 2010. (ADAMS Accession No. ML102861764)

Hora, S.C., Detlof, W and Trauth, K.M., 1991, “*Expert Judgment on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant,*” page ES-8, SAND90-3063, Sandia National Laboratories, Albuquerque, NM.

NRC, 1981, NUREG-0782, Vol. 2, page 4-53, “*Draft Environmental Impact Statement on 10 CFR Part 61, ‘Licensing Requirements for Land Disposal of Radioactive Waste*.”

National Academy of Sciences, 1995, “*Technical Bases for Yucca Mountain Standards*,” page 122, National Academy Press, Washington, D.C.

Appendix F: Analysis of Public Comments Received on NRC's Low-Level Waste Management and Volume Reduction Policy Statement Related to the Concentration Averaging Branch Technical Position

In October, 2011, NRC received comments from eight Non-Governmental Organizations related to the Concentration Averaging Branch Technical Position (BTP), principally on LLRW blending (ADAMS Accession No. ML11291A139). The comments were provided in response to an NRC notice concerning revisions to its Volume Reduction Policy Statement (VRPS) (*Federal Register,* August 15, 2011). These comments were not analyzed in preparing a final Policy Statement, since they were not within the scope of that effort. However, they are presented below, along with a staff response for each, since they concern positions in the BTP. Almost all of the issues raised by the commenters that concerned LLRW blending were extensively analyzed in SECY-10-0043, "Blending of Low-Level Radioactive Waste." The Commission issued its decision to revise the agency position on LLRW blending, including blending positions in the 1995 BTP, in its Staff Requirements Memorandum for this SECY issued on October 13, 2011 (ADAMS Accession No. ML102861764).

Additional information the Volume Reduction Policy Statement revisions can be found in SECY-12-0003, "Draft Final Policy Statement on Volume Reduction and Low-Level Radioactive Waste Management," issued on January 9, 2012 (ADAMS Accession No. ML113400169). NRC published the final revised Policy Statement (77 *Federal Register*, 25760; May 1, 2012).

1. The NRC should reject the proposal for waste blending. There is no reason for the NRC to embark upon an overhaul of its policies on Volume Reduction and Low-Level Radioactive Waste Management. There is no need to rework a key section of NRC policy to address a problem which no longer exists (disposal of Class B and C wastes).

   Staff Response:

   The staff extensively analyzed the issues associated with LLRW blending in SECY-10-0043, including impacts on Class B/C disposal and many other issues. The Commission approved revisions to NRC's position on LLRW blending in its Staff Requirements Memorandum for SECY-10-0043, "Blending of Low-Level Radioactive Waste," dated October 13, 2010 (ADAMS Accession No. ML102861764). The above comment was received in October 2011, after the Commission had made its decision.

2. Due to the opening of the WCS [Waste Control Specialists] disposal facility in Texas, there is no need to revise the policy to allow blending.

   Staff Response:

   The staff and Commission considered a wide variety of policy, regulatory, and technical (safety) issues in considering whether to revise NRC's position on LLRW blending, including issues identified by WCS in commenting on LLRW blending. In addition, blending has never been prohibited by NRC's regulations.

3. The revised policy statement is at odds, on a technical level, with the NRC's policy on blending. Volume reduction increases the concentration of Class A waste closer to the Class A limit, encouraging the production of waste not considered in the Environmental Impact Statement (EIS).

   Staff Response:

   The Policy Statement does not specifically address blending (the term "blending" is not in the Policy Statement itself) and there are no inconsistencies between the Policy Statement and the Commission's decision on LLRW blending.

   With respect waste not considered in the EIS for 10 CFR Part 61, this issue was considered in SECY-10-0043, "Blending of Low-Level Radioactive Waste." It is possible that large amounts of blended LLRW would be different from the waste streams analyzed in the draft EIS for 10 CFR Part 61 and require an analysis to ensure safe disposal. The ongoing site-specific analysis rulemaking will ensure that such wastes are analyzed and are safe for disposal. SECY-10-0043 discusses this issue extensively.

4. Large-scale blending is inconsistent with the technical basis for 10 CFR Part 61 and a case-by-case performance assessment is completely inadequate to deal with the proposed changes in NRC's blending position.

   Staff Response:

   As stated in response to comment no. 3, a site-specific analysis will ensure that disposal of blended waste is safe. Site-specific analyses for waste disposal is widely used to ensure safe disposal of wastes, and the Commission has approved the incorporation of site-specific analyses into NRC's disposal regulations in 10 CFR Part 61. That rulemaking process is now underway, with a proposed rule to be sent to the Commission in late 2013.

5. Blending of LLRW would require a new National Environmental Policy Act (NEPA) document (EIS) before any new position could be put into place.

   Staff Response:

   The NRC assumes that this commenter meant that Federal action authorizing blending of LLRW (not blending of LLRW by private entities) would require a new NEPA document. This issue was examined in SECY-10-0043. As noted in that paper, a rulemaking on blending would require a NEPA analysis, though not necessarily an EIS. NRC staff is developing an environmental evaluation of blending and alternatives to large-scale blending that is due to be completed in mid-2012. Although not required, NRC staff initiated this evaluation in response to stakeholder requests. SECY-10-0043 contains additional details on this evaluation and the applicability of NEPA.

6. NRC should prohibit disposal of blended waste at current LLRW facilities until the NEPA process is complete.

7. NRC is finalizing its policy change/clarification now, when its own technical analysis is not even expected until January 2012, clearly indicating the industry driven policy comes first then the so-called "science" to back up that policy.

   Staff Response to comment nos. 6 and 7:

   The NRC analyzed the safety of the disposal of large amounts of blended LLRW in disposal sites in SECY-10-0043, "Blending of Low-Level Radioactive Waste" and concluded that, for the sites analyzed, an increase in the amount of disposed waste at or just below the Class A limits, as could occur with intentionally blended waste, can be safely disposed of. The staff also notes that the amount of LLRW to be disposed of has not increased above the maximum inventory limits established by the licensed waste disposal facility. The NRC also published guidance for Agreement State regulators on how to evaluate the disposal of such wastes.

   As noted earlier, although not required, NRC committed to perform an environmental analysis of large-scale blending and its alternatives, and this report is expected to be completed in mid-2012. In the meantime, any disposal actions not currently captured in a licensee's license would need to be approved by the regulator of a disposal facility.

8. Waste blending would dramatically transform the waste that comes to Utah. It offers a loophole to bypass our ban on Class B and C wastes, and locks Clive in as the sole depository for nearly all the nation's LLRW.

   Staff Response:

   The Low-Level Radioactive Waste Policy Amendments Act of 1985 authorized States to enter into compacts to facilitate the export and import of LLRW between States and to encourage establishment and operation of regional LLRW disposal facilities. These disposal facilities are regulated under the NRC's regulations in 10 CFR Part 61 and by equivalent regulations that have been adopted by Agreement States. The NRC analyzed the safety of the disposal of large amounts of blended LLRW in disposal sites in SECY-10-0043, "Blending of Low-Level Radioactive Waste" and concluded that, for the sites analyzed, an increase in the amount of disposed waste at or just below the Class A limits, as would occur with intentionally blended waste, can be safely disposed of. The staff also notes that the amount of LLRW to be disposed of has not increased above the maximum inventory limits established by the licensed waste disposal facility. The NRC also published guidance for Agreement State regulators on how to evaluate the disposal of such wastes.

   In addition, waste blending, as described in SECY-10-0043, would not involve disposal of Class B/C wastes at the Clive facility. Clive is licensed to receive Class A wastes, i.e., wastes with radionuclides in concentrations up to the Class A limits in the Agreement State regulations that are equivalent to NRC's 10 CFR § 61.55, "Waste classification." The facility would still only be receiving wastes, including blended waste, classified as Class A.

9. The NRC should pursue avenues for disposal of long-lived sources that are currently stored by licensees because they have no reasonable method for disposal.

Staff Response:

The staff agrees. The NRC prefers the disposal of long-lived sources as opposed to storage. The NRC is addressing this issue in its regulatory framework by revising the BTP to specify larger activity limits of sealed sources that can be safely disposed of (changed the Cs-137 sealed source limit from 1.1 TBq (30 Ci) to 4.8 TBq (130 Ci), and Class B Co-60 limit from 25.8 TBq (700 Ci) to no limit), and through participation on the Radiation Source Protection and Security Task Force.

Appendix G: December 13, 2011, ACRS Letter to Chairman Jaczko, NRC, on Revised Branch Technical Position on Concentration Averaging and Encapsulation

ADAMS Accession No. ML11354A407

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

December 13, 2011

The Honorable Gregory B. Jaczko
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REVISED BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION OF LOW-LEVEL RADIOACTIVE WASTE

Dear Chairman Jaczko:

During the 589th meeting of the Advisory Committee on Reactor Safeguards (ACRS), December 1-3, 2011, we reviewed the staff's draft Branch Technical Position (BTP) on Concentration Averaging and Encapsulation, Revision 1, for disposal of low-level radioactive waste (LLRW). Our Radiation Protection and Nuclear Materials Subcommittee also reviewed this matter and associated issues on October 4, 2011. During these meetings, we had the benefit of discussions with representatives of the NRC staff and the Department of Energy. We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. The revised BTP should be issued for public comment after consideration of our comments.

2. The guidance provided in the revised BTP on alternative approaches provides flexibility to LLRW generators and disposal licensees, and is a good first step in improving management of LLRW.

3. The guidance provided in the revised BTP for blending LLRW is also a good approach for managing LLRW. However, the staff should continue to develop appropriate guidance to ensure that constituents in blended wastes are compatible and will result in satisfactory waste forms.

4. The staff's approach to protect an inadvertent intruder from exposure to disposed LLRW uses generic, stylized bounding calculations that assume a fixed set of conditions to judge the acceptability of disposal of LLRW. This approach does not consider site specific physical or design features that would impact the likelihood of inadvertent intrusion. The use of stylized scenarios should be replaced with an approach that takes into consideration site-specific geohydrological features, depth of burial, waste characteristics, engineered disposal features, and their degradation over time.

5. If the staff believes that 10 CFR Part 61 constrains the use of a more risk-informed, performance-based treatment of intruder scenarios, then we recommend using the same scenarios used to develop 10 CFR Part 61 without creating additional unrealistic scenarios to determine allowable concentrations or amounts of LLRW to be disposed.

BACKGROUND

On April 7, 2010, the staff transmitted SECY-10-0043, "Blending of Low-Level Radioactive Waste," with a recommendation that the Commission adopt a risk-informed, performance-based approach to LLRW blending. In a Staff Requirements Memorandum (SRM) dated October 13, 2010, the Commission approved the staff's plan and directed that the staff develop a revised BTP addressing the circumstances under which large-scale blending would be acceptable. This SRM also directed the ACRS to review the revised BTP prior to being issued for public comment.

DISCUSSION

The following discussion provides comments on four main topics in the revised BTP. These topics are guidance on alternative approaches, guidance on blending of LLRW, guidance on encapsulation of LLRW, and updates to the intruder scenarios.

<u>Guidance on Alternative Approaches</u>

The BTP has been revised to remove the restrictive Alternative Provision section from the 1995 version of the BTP and to provide applicable "look up" guidance for users of the BTP on alternative ways to address site-specific considerations to meet the provisions of the BTP. The staff stated they will include additional examples to demonstrate the use of the Alternative Approaches section of the revised BTP including factors such as likelihood of intrusion, large component disposal, and encapsulation of sealed sources. This approach will provide greater flexibility than the guidance in the 1995 version of the BTP.

Guidance on Blending of LLRW

The BTP has been revised to provide a method to average radionuclide concentrations of radioactive materials contained in packages of "blended" LLRW to assess conformance with the protection requirements for a hypothetical inadvertent intruder. The revised BTP removes several unnecessary conservatisms from its 1995 version. For example, the revised BTP removes the factor of 10 constraint for blending wastes[19] and the exceptions previously in place for homogeneous wastes.

The revised BTP also provides guidance by which to evaluate radioactive material homogeneity in wastes for the purpose of protecting inadvertent intruders (e.g. resident farmers, homesteaders, and others) from exposure scenarios consistent with those evaluated during the promulgation of 10 CFR Part 61. The staff's approach is consistent with Commission direction to revise the BTP regarding the circumstances under which large-scale blending would be acceptable.

Blending involves mixing of potentially large volumes of multiple classes of waste which when aggregated will be classified as a lower class of waste. This process is intended to create blended wastes that will meet Class A requirements. Care must be taken however, to assure that the final waste product will have appropriate physical and chemical characteristics so that the waste will meet all requirements for the entire period of performance. For example, blending resins of different forms (organic/styrene with mineral/chabazite/silica) may create or result in a final waste form with undesirable chemical characteristics, such as gas generation, that are not intended, or physical characteristics that cause the waste form to behave in undesirable ways.

Blending waste forms to achieve class reduction and or volume reduction should be preceded by tests or other actions to ensure that the final waste form has the required chemical and physical characteristics.

Guidance on Encapsulation

The BTP has been revised to provide additional guidance on encapsulation of wastes, specifically to address disposal of sealed sources. The limits on the disposal of these sources are driven by the consideration of inadvertent intruders.

The scenarios used to develop the limits on the encapsulation of sealed sources in the revised BTP are overly conservative. They are based on postulated future intrusion by persons with no knowledge regarding the disposed radioactive materials. These intruders are assumed to be

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[19] Section 3.1 Mixing of homogeneous waste types or streams, of the 1995 version of the BTP states, "Under the guidance in this position, the classification of a mixture, using the sum of fractions rule specified in 10 CFR 61.55, should be based on either: (a) the highest nuclide concentrations in any of the individual waste types contributing to the mixture; or (b) the volumetric or weight-averaged nuclide concentrations of the mixture; provided that the concentrations of the individual waste type contributors to the mixture are within a factor of 10 of the average concentration of the resulting mixture." The guidance in the revised BTP does not contain the "factor of 10" guidance described in Item (b).

unable to recognize or determine that they are on a radioactive waste disposal facility. They do not take into consideration important elements such as the depth of burial.

The scenarios are also inconsistent with the scenarios used in development of 10 CFR Part 61, which themselves are overly conservative.

Regarding the inability of intruders to recognize the presence of a radioactive waste disposal site, in the Environmental Impact Statement (EIS) supporting 10 CFR Part 61, the intruder scenario most relevant to the encapsulated source is intruder discovery (exposure to an individual who digs into the waste, realizes something is wrong and ceases his excavation activities). The scenario used to calculate the limits in the revised BTP, where an item of waste, such as a sealed source, is discovered and carried away, was not considered likely in the EIS.

It is possible to consider new waste streams using the same assumptions as in 10 CFR Part 61 without creating additional stylized scenarios to determine allowable concentrations or amounts of disposed LLRW. If the staff believes 10 CFR Part 61 constrains the use of a more risk-informed, performance-based treatment of intruder scenarios in the revised BTP, then we recommend using the same scenarios used to develop 10 CFR Part 61.

Improving the Intruder Scenarios Evaluated in the BTP

In the EIS supporting 10 CFR Part 61 three intrusion events were considered. The events were characterized as "intruder construction (exposure to workers constructing a house at the site), intruder agriculture (exposure to individuals living in the house constructed and consuming food grown onsite), and intruder discovery (exposure to an individual who digs into the waste, realizes something is wrong and ceases his excavation activities)."

The use of a limited number of predefined stylized scenarios that presume an intruder would make direct contact with buried wastes does not realistically account for site-specific features that affect either the likelihood or the consequences of an intrusion event. Such scenarios should be replaced with an approach that takes into consideration site-specific geohydrological features, depth of burial, waste characteristics, engineered disposal features, and their degradation over time.

The approach to developing intruder scenarios in the revised BTP also does not account for improvements in management practices made since promulgation of 10 CFR Part 61 that make intrusion less likely. Current disposal facilities have collected large perpetual care funds that provide for monitoring and maintenance over much longer periods of time than originally assumed. Record-keeping and information management technology have improved to the extent that there is little chance of a complete loss of information about the locations of LLRW disposal facilities. These institutional controls make inadvertent intrusion very unlikely.

Additionally, the revised BTP does not account properly for radioactive decay and the distribution of the remaining radioactive materials in the disposal facility as a function of time. After 300 years, most radionuclides in a typical LLRW inventory would have decayed to insignificant levels, leaving behind an inventory containing mainly U-238, C-14, I-129, Tc-99, and Ni-63. Guidance considering radioactive decay should be part of the revised BTP.

The staff explained that the current institutional control requirements of the rule (§61.59) constrain their assumptions in conducting the analysis that supports the revised BTP. Specifically, the analysis supporting 10 CFR Part 61 bounds the calculation for protecting the intruder by assuming institutional controls are not relied on at the end of the control period. The EIS supporting 10 CFR Part 61 states that the "NRC does not assume that the government fails at the end of the 100-year institutional control period, but rather that the government ceases active control over access to the site. The rule does not presuppose collapse or failure of government, but rather places a restriction on the character of radioactive material disposable by near surface disposal that serves to relieve government of the burden of actively excluding persons from the site in perpetuity."

As noted previously, if the staff believes 10 CFR Part 61 constrains the use of a more risk-informed, performance-based treatment of intruder scenarios in the revised BTP, then we recommend using the same scenarios used to develop 10 CFR Part 61.

Additional Considerations Regarding Inadvertent Intrusion

The relative importance of protection of the intruder versus the other performance objectives should be reconsidered. The protection of the intruder as described in the 10 CFR Part 61 performance objective (§61.42) which states, "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 contacting the waste at any time after active institutional controls over the disposal site are removed," should not overshadow the other performance objectives of 10 CFR Part 61 in any analyses conducted to support implementation of the rule. These are:

- protection of the general population from release of the radioactive materials over the period of performance (§61.41),
- protection of workers from unnecessary occupational exposure (§61.43), and
- stability of the disposal site after closure (§61.44).

As stated in our September 22, 2011, report on 10 CFR Part 61 rulemaking, the use of overly conservative scenarios "for inadvertent intrusion into presumably abandoned, unmarked, and unsecured LLRW disposal facilities can change the focus of the facility design from the protection of the health and safety of the public during the period of operation of the facility (and a reasonable period thereafter), to the protection of hypothetical intruders many thousands of years in the future."

We look forward to additional discussions with the staff on the guidance in the revised BTP.

Dr. Dana Powers did not participate in the Committee's discussions regarding this matter.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

REFERENCES

1. U.S. Nuclear Regulatory Commission, "*Draft Branch Technical Position on Concentration Averaging and Encapsulation, Revision 1*," August 2011 (ML112490287)

2. U.S. Nuclear Regulatory Commission, Title 10 Code of Federal Regulations, Part 61, "*Licensing Requirements for Land Disposal of Radioactive Waste*," 1982

3. U.S. Nuclear Regulatory Commission, SECY-10-0043, "*Blending of Low-Level Radioactive Waste*," April 7, 2010 (ML090410246)

4. U.S. Nuclear Regulatory Commission, Staff Requirements Memorandum (SRM)-SECY-10-0043, "*Blending of Low-Level Radioactive Waste*," October 13, 2010 (ML102861764)

5. ACRS Letter, "*Proposed Rulemaking to Introduce a Site-Specific Performance Assessment and Human Intrusion Analysis Requirement to 10 CFR Part 61*," dated September 22, 2011 (ML11256A191)

6. U.S. Nuclear Regulatory Commission, "*Final Branch Technical Position on Concentration Averaging and Encapsulation*," January 17, 1995 (ML033630732)

7. U.S. Nuclear Regulatory Commission, "*Final Environmental Impact Statement on 10 CFR Part 61, 'Licensing Requirements for Land Disposal of Radioactive Waste*,'" NUREG-0945, Volumes 1 through 3, November 1982 (ML052590184, ML052920727, ML052590187)

Appendix H: NRC Staff Response to ACRS Letter on Revised Branch Technical Position on Concentration Averaging and Encapsulation

(February 3, 2012 Letter from R.W. Borchardt to Dr. Said Abdel-Khalik, ACRS)

ADAMS Accession No. ML120090314

February 3, 2012

Dr. Said Abdel-Khalik, Chairman
Advisory Committee on
Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: RESPONSE TO ADVISORY COMMITTEE ON REACTOR SAFEGUARDS REPORT ON THE REVISED BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

Dear Dr. Abdel-Khalik:

During the 589th meeting of the Advisory Committee on Reactor Safeguards (ACRS or the Committee) held on December 1, 2011, the ACRS completed its review of a draft revision to the staff's Branch Technical Position (BTP) on Concentration Averaging and Encapsulation. The Radiation Protection and Nuclear Materials Subcommittee of the ACRS also reviewed this document in its meeting on October 4, 2011. The Committee provided the Commission with conclusions and recommendations in a letter dated December 13, 2011.

We appreciate the Committee's in-depth review of the draft revised BTP, as well as the support for a number of the proposed positions in the revised BTP. These positions include the addition of the Alternative Approaches section and the new guidance on blending of certain low-level radioactive waste (LLRW) streams. The Committee has also recommended that the staff's generic positions be replaced by an approach that takes into consideration site-specific analyses performed by licensees. The staff agrees that site-specific analyses may be beneficial, but believes that licensees should continue to have an option to use the generic positions in the BTP, if they so choose. The generic positions in the current and draft revised BTP allow for the classification of LLRW, without the burden of performing a special analysis. Staff responses to the five conclusions and recommendations in your December 13, 2011, letter are provided below.

1. <u>The revised BTP should be issued for public comment after consideration of the Committee's comments.</u>

   The staff appreciates the insight and guidance of the ACRS and, as recommended, the BTP will be revised and then issued for public comment, after consideration of the ACRS comments. The staff intends to acknowledge and identify the ACRS's views on the revised BTP in the announcement for the public comment period.

2. The guidance provided in the revised BTP on alternative approaches provides flexibility to LLRW generators and disposal licensees, and is a good first step in improving management of LLRW.

   The staff appreciates the ACRS's support of this new section. The Alternative Approaches section was added to the revised BTP to provide licensees and Agreement States with NRC guidance for proposing site- and waste-specific alternatives to the "look-up" positions in the BTP.[20] While these generic positions do not require individual approval, and therefore are easy-to-use and efficient, they are also conservative to compensate for the broad range of site- and waste-specific features that may be encountered. This new section is performance-based in that it enables licensees to use more than one approach to achieve the performance objective of protecting an inadvertent intruder.

   The BTP's generic positions and the Alternative Approaches are different and intended to complement each other. The Alternative Approaches specifically allow consideration of site- and waste-specific features, such as depth of burial, waste characteristics and engineered disposal features, to demonstrate that an inadvertent intruder can be protected. For example, the BTP generic guidance for encapsulation and disposal of Cs-137 sealed radioactive sources is that sources less than 130 Ci can be disposed of without further review. If a source's activity exceeds the generic limits (130 Ci for Class C disposal of Cs-137 sources), alternative approaches are available for licensees to use. The use of site- or waste-specific factors would require a licensee to develop a technical justification and to seek regulatory approval of higher activity limits.

3. The guidance provided in the revised BTP for blending is also a good approach for managing LLRW. However, the staff should continue to develop appropriate guidance to ensure that constituents in blended wastes are compatible and will result in satisfactory waste forms.

   The staff continues to improve the bases for the blending positions while continuing to work to ensure there are no unintended consequences. The staff appreciates the ACRS's comment and agrees that the waste constituents and their effect on final waste forms is an important issue that requires further consideration for the revisions to the BTP.

4. The staff's approach to protect an inadvertent intruder from exposure to disposed LLRW uses generic, stylized bounding calculations that assume a fixed set of conditions to judge the acceptability of disposal of LLRW. This approach does not consider site-specific physical or design features that would impact the likelihood of inadvertent intrusion. The use of stylized scenarios should be replaced with an approach that takes into consideration site-specific

[20] "Look-up" positions are methods that licensees may generally use to demonstrate that the averaging provisions in 10 CFR 61.55(a)(8) have been met, without having to prepare a special analysis to justify an alternative approach or receive specific approval by the regulator.

geohydrological features, depth of burial, waste characteristics, engineered disposal features, and their degradation over time.

The staff agrees with the ACRS's recommendation that site- and waste-specific features (such as depth of burial and waste characteristics) should be taken into account in protecting the inadvertent intruder and defining positions for averaging of LLRW for waste classification, where necessary. However, the staff believes that the look-up provisions that are based on generic, stylized scenarios should continue to be included in the BTP to offer licensees a choice in how they demonstrate protection of an inadvertent intruder and use of appropriate concentration averaging techniques. If a disposal facility licensee wishes to use site- or waste-specific information to justify averaging methods different from the generic guidance in the BTP, as the ACRS has suggested, the Alternative Approaches section of the revised BTP explicitly acknowledges that possibility and provides guidance for site-specific approaches. The staff believes that the BTP should give licensees a choice, because both approaches can provide for the necessary protection of an inadvertent intruder.

In preparing this revised BTP, the staff has focused on improving the existing guidance contained in the 1995 BTP. The positions in the 1995 BTP and the revised draft are based on generic radiation exposure scenarios that are different from those used in developing the 10 CFR 61.55 waste classification tables. The staff believes that additional scenarios, beyond those considered in the development of the 10 CFR 61.55 tables, should be considered to ensure protection of intruders from hot spots in the waste. In the staff's proposed revisions, the staff has made the scenarios more realistic than those used in the 1995 BTP. These revisions will enable the safe disposal of, for example, larger activity sealed sources that are not now recommended for Part 61 disposal because the 1995 BTP is more conservative.

5. If the staff believes that 10 CFR Part 61 constrains the use of a more risk-informed, performance-based treatment of intruder scenarios, then we recommend using the same scenarios used to develop 10 CFR Part 61 without creating additional unrealistic scenarios to determine allowable concentrations or amounts of LLRW to be disposed.

   The staff believes that the proposed scenarios are appropriate to set generic limits for specific waste streams that were not fully evaluated in developing 10 CFR Part 61, such as encapsulated small gamma-emitting items. These scenarios are not unlike design basis accidents used in the nuclear reactor program. The scenarios used to set the 10 Part 61.55 disposal concentration limits are based on the assumption that waste is either: (1) soil-like and unrecognizable; or (2) intact and recognizable as being hazardous within 6 hours of discovery.

   The consequences of accidents involving small gamma-emitting sealed radioactive sources were a factor leading to the development of another scenario for the 1995 BTP, in which a small piece of gamma-emitting material is intact, but not recognizable as being hazardous. The staff believes this approach is needed to protect "a person who might occupy the disposal site after closure and engage in normal activities … or other pursuits in which the person might be unknowingly exposed to radiation from the waste" (10 CFR 61.2). Another factor in the use of the additional generic scenarios is that they provide a basis for constraining the amount of averaging that is performed for hot spots, which enhances regulatory stability by limiting the amount of waste that could change waste classification under a revised BTP.

The Committee's December 13, 2011, letter also contained a discussion of other issues related to intruder protection, such as reliance on funding for perpetual control of sites and the relative importance of intruder protection in comparison with other 10 CFR Part 61 performance objectives. As discussed with the Committee on July 13, 2011, the Commission has directed the staff to consider a comprehensive revision to 10 CFR Part 61. SECY-10-0165, "Staff's Approach to Comprehensive Revision to 10 CFR Part 61," outlines the staff's plan for responding to the Commission. This plan will be revised in response to recent Commission direction on the Part 61 rulemaking in the Staff Requirements Memorandum for COMWDM-11-0002/COMGEA-11-0002, "Revision to 10 CFR Part 61." In developing the staff's analysis of alternatives and issues associated with revising 10 CFR Part 61, the staff will consider these other issues raised by the ACRS in its December 13, 2011, letter.

The staff appreciates the ACRS's thorough review of the proposed revisions to the BTP on Concentration Averaging and Encapsulation, and looks forward to continued interactions on the proposed final version.

Sincerely,

/RA Michael Weber for/

R. W. Borchardt
Executive Director
for Operations

cc: Chairman Jaczko
Commissioner Svinicki
Commissioner Apostolakis
Commissioner Magwood
Commissioner Ostendorff
SECY

Appendix I: Major Changes from 1995 to May 2012 BTP

1. Added Glossary of Terms.
2. The definition of “classification-controlling” was changed to match the common sense definition of the term – that is, one or more nuclides, listed in Table 1 or Table 2 of 10 CFR § 61.55, whose concentration is the specific basis for the classification of the waste container. A new title, “nuclide(s) of concern,” was given to the existing 1995 definition of “classification controlling” nuclides (i.e., the 1995 definition was not changed, but the definition has a new name, “nuclide(s) of concern”).
3. Removed the Factor of 10 Rule for mixing similar homogeneous waste types, consistent with Commission decision in SRM-SECY-10-0043.
4. Added a test for homogeneity for mixable wastes.
5. Removed “designed collection of homogeneous waste from a number of sources within a licensee’s facility, for purposes of operational efficiency or occupational dose reduction,” consistent with Commission decision in SRM-SECY-10-0043.
6. Guidance for classifying activated metals, contaminated materials and cartridge filters is combined. The 1995 BTP provided separate guidance for classifying (1) activated metals, (2) contaminated materials, and (3) cartridge filters.
7. Defined conditions under which a mixture of cartridge filters may be treated as a homogeneous waste type.
8. Changed the Factor 1.5 Rule to a Factor of Two Rule. The Factor of Two Rule is now linked to the classification limit (Class A, B or C) of the mixture, and not linked to the average concentration of the mixture, making it more risk-informed.
9. The Factor of 10 Rule is now linked to classification limit (Class A, B or C) of the mixture, and not linked to the average concentration of the mixture, making it more risk-informed.
10. In the 1995 BTP, if the non-primary gamma emitters control the classification of a mixture, then each non- primary gamma-emitting classification controlling nuclide, in each piece, should meet the Factor of 10 Rule. This has been revised and now, if the non-primary gamma emitters control the classification of a mixture, then each “nuclide of concern” (including the primary gamma-emitters) in each piece, should meet the Factor of 10 Rule.
11. For Table A, the word “Potentially” has been removed from the Table’s title, and the Table A test applies to all pieces in a mixture, to be consistent with text in the 1995 BTP. .
12. Changed the Cs-137 Ci source Class C limit from 30 Ci to 130 Ci based on a new sealed source scenario.
13. Changed the Co-60 Ci source activity limits for Class A from 700 Ci to 140 Ci, and for Class B from 700 Ci to no limit, based on a new sealed source scenario.

14. Clarified use of 10 CFR § 61.58 as applicable to alternatives to certain regulatory *requirements* as defined in § 61.58, and not applicable to alternatives to guidance in the BTP.
15. Added statement that licensees may use larger volumes for averaging of encapsulated waste previously approved by NRC in topical reports.
16. Added Alternative Approaches for Averaging section to BTP.
17. Altered and clarified the Technical Basis for Concentration Averaging and Encapsulation Guidance (Appendix B).
18. Added Appendices with responses to stakeholder comments.
19. Added ACRS letter to NRC Commission on BTP and staff's response to ACRS in Appendices.
20. Added Safety Culture Policy Statement in Appendix J, and text from the Policy Statement in the body of the BTP.
21. Renumbered sections of 1995 BTP.

Appendix J: Safety Culture Statement of Policy

The safety culture policy statement was published in the Federal Register (76 FR 34773) on June 14, 2011 and can be found at: http://www.gpo.gov/fdsys/pkg/FR-2011-06-14/pdf/2011-14656.pdf. It is also posted in NRC's Agencywide Documents Access and Management System (ADAMS) Accession Number ML11146A047.

Safety Culture Policy Statement

The purpose of this Statement of Policy is to set forth the Commission's expectation that individuals and organizations establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions. This includes all licensees, certificate holders, permit holders, authorization holders, holders of quality assurance program approvals, vendors and suppliers of safety-related components, and applicants for a license, certificate, permit, authorization, or quality assurance program approval, subject to NRC authority. The Commission encourages the Agreement States, Agreement State licensees and other organizations interested in nuclear safety to support the development and maintenance of a positive safety culture, as articulated in this Statement of Policy.

Nuclear Safety Culture is defined as the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment. Individuals and organizations performing regulated activities bear the primary responsibility for safety and security. The performance of individuals and organizations can be monitored and trended and therefore, may be used to determine compliance with requirements and commitments and may serve as an indicator of possible problem areas in an organization's safety culture. The NRC will not monitor or trend values. These will be the organization's responsibility as part of its safety culture program. Organizations should ensure that personnel in the safety and security sectors have an appreciation for the importance of each, emphasizing the need for integration and balance to achieve both safety and security in their activities. Safety and security activities are closely intertwined. While many safety and security activities complement each other, there may be instances in which safety and security interests create competing goals. It is important that consideration of these activities be integrated so as not to diminish or adversely affect either; thus, mechanisms should be established to identify and resolve these differences. A safety culture that accomplishes this would include all nuclear safety and security issues associated with NRC regulated activities.

Experience has shown that certain personal and organizational traits are present in a positive safety culture. A trait, in this case, is a pattern of thinking, feeling, and behaving that emphasizes safety, particularly in goal conflict situations, e.g., production, schedule, and the cost of the effort versus safety. It should be noted that although the term 'security'' is not expressly included in the following traits, safety and security are the primary pillars of the NRC's regulatory mission. Consequently, consideration of both safety and security issues, commensurate with their significance, is an underlying principle of this Statement of Policy.

The following are traits of a positive safety culture:

1. Leadership Safety Values and Actions—Leaders demonstrate a commitment to safety in their decisions and behaviors;
2. Problem Identification and Resolution—Issues potentially impacting safety are promptly identified, fully evaluated, and promptly addressed and corrected commensurate with their significance;
3. Personal Accountability—All individuals take personal responsibility for safety;
4. Work Processes—The process of planning and controlling work activities is implemented so that safety is maintained;
5. Continuous Learning—Opportunities to learn about ways to ensure safety are sought out and implemented;
6. Environment for Raising Concerns—A safety conscious work environment is maintained where personnel feel free to raise safety concerns without fear of retaliation, intimidation, harassment, or discrimination;
7. Effective Safety Communication—Communications maintain a focus on safety;
8. Respectful Work Environment—Trust and respect permeate the organization; and
9. Questioning Attitude—Individuals avoid complacency and continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.

There may be traits not included in this Statement of Policy that are also important in a positive safety culture. It should be noted that these traits were not developed to be used for inspection purposes. It is the Commission's expectation that all individuals and organizations, performing or overseeing regulated activities involving nuclear materials, should take the necessary steps to promote a positive safety culture by fostering these traits as they apply to their organizational environments. The Commission recognizes the diversity of these organizations and acknowledges that some organizations have already spent significant time and resources in the development of a positive safety culture. The Commission will take this into consideration as the regulated community addresses the Statement of Policy.