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An Evaluation of Alternative Classification Methods for Routine Low Level Waste from the Nuclear Power Industry

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An Evaluation of Alternative Classification Methods for Routine Low Level Waste From the Nuclear Power Industry

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Final Report, November 2007

EPRI Project Manager
P. Tran

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

DW James & Associates

Vance & Associates

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

CITATIONS

This report was prepared by

DW James & Associates
855 Village Center Drive #330
St. Paul, Minnesota 55127

Principal Investigator
D. James

Vance & Associates
PO Box 997
Ruidoso, New Mexico 88345

Principal Investigator
J. Vance

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REPORT SUMMARY

This report investigates the feasibility of classifying all routine nuclear power plant low level waste, including Class B and Class C waste, as Class A low level waste within the framework of NRC regulatory requirements. A change in classification could expand disposal venues and reduce the uncertainty of future disposal. The report shows that all of the waste, when managed as a composite stream, will meet the requirements for Class A disposal without leaving a portion of the stream orphaned to on-site retention.

Background

This report is a continuation of efforts begun by EPRI in 2005 to reopen the discussion of regulations and regulatory guidance relating to low level waste disposal. Of principal concern is the lack of progress in developing low level waste disposal sites pursuant to the Low Level Waste Policy Act of 1980 (LLWPA) and the Low Level Waste Policy Amendments Act of 1985 (LLWPAA). Since their enactments, no new sites have evolved through the compacting process defined in the Acts, and in fact, there has been a steady loss of disposal options. The Barnwell disposal site is scheduled to close in 2008, which will eliminate the last venue for disposal of Class B and Class C low level waste.

The industry has considered several options, including revising the 10CFR61 regulation governing operation and licensing of disposal sites, or changing the averaging constraints without touching the regulation. Utilities generally recognize that the first option is a long-term effort that would provide little immediate relief to operating facilities. The second option provides a potentially easier track since it only affects NRC-controlled regulatory guidance without formal rulemaking. A third option, which more directly addresses the approach taken in this study, is to revisit the requirements and interpretation of 10CFR61, which sets criteria and concentration limits for licensing and operating a disposal site. The regulation does not define a waste package as the primary unit for disposal classification or set parameters for defining a waste package.

The approach taken in this study extends classification to a larger volume of material while still maintaining connection with the regulatory limits and objectives of the averaging criteria. The material volume proposed as an averaging volume is determined in the 10CFR61 Environmental Impact Statement as “that which might reasonably be expected to be excavated by a future intruder for non-commercial activities.”

Objectives

- To integrate recent experience into industry LLW source term estimates and to use the updated estimates to determine disposability of industry-wide streams as Class A waste.

- To examine operating practices as they relate to classification of low level waste and proposed practices to minimize Class B and Class C waste disposal.
- To investigate and evaluate the basis for 10CFR61.55 concentration limits.

Approach
The project team collected and compiled radioactive waste shipment data from EPRI members. The waste includes ion-exchange resins, filter media, cartridge filters, DAW, concentrates, charcoal, etc. 41 plants, comprising 65 of 100 operating units, responded to the survey request and contributed about 10,000 individual data entries. The project team compiled the data in spreadsheets based on plant type and waste stream, and evaluated it for disposal classification.

Results
The project team found that all routine process wastes (including resins and filters) could likely be conformed to Class A disposal requirements, while remaining within the basic 10CFR61 regulatory structure. Regulators could accomplish this by expanding the basic unit for classification from a "package" to a disposal volume unit that would occupy the equivalent of the volume that would be excavated by a potential disposal site intruder.

The changes to disposal practices proposed in this study would require NRC recognition of the practices in technical positions, and inspection and enforcement guidelines for power plants, processors, and disposal sites. The proposed changes would impact power plant operating practices, may initiate new commercial waste processing options, and could potentially impact disposal site waste acceptance processes and operations.

EPRI Perspective
This effort represents a view to long term resolution of low level waste disposal issues. It could only be undertaken where there is some detachment from short term interests and freedom to pursue investigations that may not have immediate payback. EPRI occupies a unique position with access to the type of data needed to conduct this evaluation, as well as the mandate of its members to identify and address future issues and problems.

Keywords
Low level waste
10CFR 61
Disposal
Concentration averaging
Barnwell closure
LLW source term

ACKNOWLEDGMENTS

We are pleased to acknowledge the broad participation of EPRI member utilities in consenting to allow their data to be included in the database used for this evaluation. The names of those stations are listed below. We would like to especially acknowledge the support provided by WMG, Inc. in translating data from shipping records stored using their software. John LePere of WMG was particularly instrumental in providing this information in a timely usable format for our investigation.

Arkansas Nuclear One

Beaver Valley

Braidwood

Brunswick

Byron

Callaway

Calvert Cliffs

Catawba

Clinton

Columbia

Comanche Peak

Dresden

Fitzpatrick

Fort Calhoun

Ginna

Grand Gulf

Indian Point

Kewaunee

Lasalle

Limerick

Mcguire

Millstone

Monticello

Nine Mile Point

North Anna

Oconee

Oyster Creek

Peach Bottom

Pilgrim

Prairie Island

Quad Cities

River Bend

Seabrook

South Texas

St. Lucie

V.C. Summer

Surry

Susquehanna

Three Mile Island

Vermont Yankee

Waterford

Wolf Creek

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1 EXECUTIVE SUMMARY

This report reflects a continuation of efforts began in 2005 to reopen the discussion of regulations and regulatory guidance relating to low level waste disposal. Of principal concern is the lack of progress in developing low-level waste disposal sites pursuant to the Low Level Waste Policy Act of 1980 (LLWPA) and the Low Level waste Policy Amendments Act of 1985 (LLWPAA). Since their enactments no new sites have evolved through the compacting process defined in the Acts and in fact there has been a steady loss of options for disposal. In 2008, the Barnwell disposal site is scheduled to close eliminating the last venue for disposal of Class B and C low level waste. The waste streams in question have traditionally been identified as suitable for shallow land disposal. NRC regulations artificially split the streams into three classification groups with the lowest classification, Class A, applied to unstabilized disposal in an unprotected trench. This approach to disposal is no longer practiced, in part, because the concentrations allowed for Class A waste went beyond the capability of this mode of disposal to provide protection. Current practice is to provide stability or intruder barriers for wastes approaching the Class A limits. These practices make it feasible to provide adequate protection for the full range of activity concentrations encountered. In addition, if disposal classification is applied on a stream wide basis, it could still be demonstrated that disposal site concentration would be in compliance with the current Class A limits. Basic options considered, in going forward with this study, included 1)revising the 10CFR 61 regulation governing the operation and licensing of disposal sites or 2) revising the Branch Technical Position on Classification to relax the averaging constraints applied to classification. Taking the first option is generally recognized as a long-term effort which would provide little immediate relief to operating facilities. The second option provides a potentially easier track since it only effects regulatory guidance which is controlled at the discretion of NRC without formal rulemaking. A third option which more directly addresses the approach taken in this study was to revisit the requirements of 10CFR61 and how they are interpreted. Basically, 10CFR 61 sets criteria and concentration limits for licensing and operating a disposal site. The regulation does not define a waste package as the primary unit for disposal classification or set parameters for defining a waste package. The approach taken in this study is to extend classification to a larger volume of material while still maintaining connection with the regulatory limits and objectives of the averaging criteria. The material volume proposed as an averaging is determined from the volume of material defined in the 10CFR61 Environmental Impact Statement as that which might reasonably be expected to be excavated by a future intruder for non-commercial activities. As an initial effort, it was determined to rebuild the source term for low-level wastes based on operating data and examine the impacts of disposing of this waste under a single classification and within the limits defined for Class A disposal by 10CFR61.

This report investigates the feasibility for classifying all routine nuclear power plant low-level waste, including waste currently defined as Class B and Class C, as Class A low level waste within the framework of NRC regulatory requirements. Tasks undertaken in this study including developing updated nuclear power plant waste stream profiles, developing a better understanding of the regulatory bases for the classification system, and reexamining the classification of these wastes if taken as a unified stream without constraints on averaging imposed by the NRC Branch Technical Position on Concentration Averaging and Encapsulation. Radioactive waste shipment data was collected from EPRI members and compiled into a database. In all 41 plants comprising 65 of 100 operating units responded to the survey request contributing about 10,000 individual data entries. This data was reconstructed in spreadsheets on the basis of plant type and waste stream and evaluated for disposal classification.

In addition, the original Draft and Final Environmental Impact Statements for the NRC Regulation Title 10 Part 61 were reviewed to gain a deeper understanding of the regulation and the bases that were used to justify it. Discussion of the intruder models used to determine the concentration limits for classification is provided in the report. Comparisons were made using the original modeling in the Draft Environmental Impact Statement with later parameter and model changes that were published in an update methodology report. It was found that much of the foundation upon which 10CFR 61 was based had changed significantly by the time of the update. Further, it was observed that the basic intruder models for 10CFR 61 had limited applicability in light of current operating disposal site practice which relies more strongly on stabilization than envisioned in the regulation.

It was found in the report that, while still remaining within the basic 10CFR61 regulatory structure, all routine process wastes (including resins and filters) could likely be conformed to Class A disposal requirements. This would be accomplished by expanding the basic unit for classification from a “package” to a disposal volume unit that would occupy the equivalent of the volume that would be excavated by a potential disposal site intruder.

With the anticipated closure of Barnwell in 2008, the disposal of Class B and C resins and filters to out of compact nuclear power industry generators will no longer be available. Unless additional disposal capability is developed for the disposal of Class B and C low-level waste, onsite storage of these wastes at generators’ facilities will be required for, what could be, an indefinite period of time. To ameliorate this situation for the nuclear power industry, it has been proposed that regulatory changes be sought in the approach to waste classification. Regulatory approval would be sought to allow nuclear plant process waste to be classified on the basis of a larger volume involving many containers that would be disposed of as a single lot rather than on an individual container basis. This multi-container classification would result in higher average radionuclide concentrations in the disposal trenches consistent with the dose assessment modeling performed by the NRC in the justification for the numerical concentration limits in 10 CFR 61. This approach will the have least impact on the current practices and would not mandate a change to 10 CFR 61 as it currently stands.

Rather then classifying resin and filter waste on a package basis, the basic premise put forward in this study is to use the “classification unit volume” represented by an assembly of packages with a collective volume equivalent to the hypothetical volume of waste posited by the NRC to be intercepted by an inadvertent intruder. We’ve termed this unit volume as the “intruder-basis volume” (IBV). The IBV would be disposed of in its entirety together and would maintain its identity in the disposal cell, thus ensuring that the 10 CFR 61 Class A concentration limits would not be exceeded. It is proposed that regulatory approval be sought to allow nuclear power plant generators to pool waste packages from their facilities and classify this waste based on an IBV. This change in classification approach could allow disposal of virtually all of the nuclear plant low-level waste in a Class A facility such as the EnergySolutions low-level waste disposal facility in Clive, Utah. Activated hardware was not specifically addressed in this examination because it is a composed of discreet items and does not fit the definition of routine process waste which had been established as the scope of this study because of the large volume of B and C waste.

The size of the IBV could not exceed the disposal unit volume established as the basis for the intruder scenarios presented in the 10 CFR 61 Environmental Impact Statement (EIS)[1] supporting the 10 CFR 61 rule. The waste included would be collected for a lot from generators' facilities and combined at the disposal site for concentration averaging and classification to assure that concentrations within the disposal unit would be within the concentration limits of 10CFR61 for Class A material. The size of an IBV is expected to be on the order of approximately 50 120 cubic foot liners. Waste would, in effect, be classified on an IBV basis involving 50 liners.

The impact on classification will also be investigated by taking into account current facility disposal practices which provide greater levels of protection than the minimal practices used as a basis for the original 10CFR61 concentration limits. The impacts would reflect the higher levels of protection being provided by current disposal practices at low-level disposal facilities such as the EnergySolutions low-level waste disposal facility in Clive, Utah. These practices include stabilization of Class A waste or deeper disposal or the layering of high and low activity waste. Current disposal site practices differ significantly from the minimal protection level posited by the NRC as being reflective of the practices back in 1980 which were the bases for the concentration limits in 10CFR61. Further, the approach suggested here attempts to remain consistent with NRC regulatory requirements and guidance and only modestly encroaches on the additional protection levels provided by current practices.

Accounting for these practices in the approach to classification would result in a larger volume of low-level waste which would be suitable for disposal at current 10 CFR 61 Class A disposal limits. If full credit was taken for current operating practices including disposal depth and structural barriers, it may be that all nuclear power plant routine process waste could be suitable for Class A disposal. The basis for seeking approval for this approach is provided in the 10 CFR61 regulations, which specifically states that; "Under 10 CFR Part 61, §61.58, the Commission may authorize other provisions for 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 compliance with the performance objectives in subpart C of 10 CFR Part 61."

It is intended that the above proposal would be in compliance with the performance objectives in Subpart C and it is not intended to alter the packaging or disposal requirements provided in 10 CFR 61. This proposal would only change the classification methodology.

[1] NUREG-0782, Draft Environmental Impact Statement for 10 CFR Part 61 Licensing Requirements for Land Disposal of Radioactive Waste, USNRC, September 1982

Report Structure

Section 2 of the Report provides an overview of the background and approach taken in developing the espoused classification approach and discusses the development of the 10 CFR 61 limits.

Section 3 of the Report provides a summary of the work performed and highlights significant conclusions drawn from this study.

Section 4 of the Report revisits the intruder analyses performed for the 10 CFR 61. A comparison is performed to evaluate differences between the original studies performed in support of the rulemaking and results obtained following the updated IMPACTS computer program published by the NRC in 1986.

Section 5 of the Report discusses the Branch Technical Position on Concentration Averaging and Encapsulation including the issues it tried to address and its basic relevance to basic 10 CFR 61 concentration limits.

Section 6 of the Report discusses the data collection effort to develop an updated industry source term. Various summary tables are provided for waste volumes and radiological characteristics broken by plant type. The data collection included shipping data from 41 of 65 currently operating facilities.

Section 7 of the report provides a classification analysis based on averaging over the industry wide data base.

Section 8 includes references used in the report.

Appendix A of the Report provides additional details on the data collected including results from individual plants. The Appendix shows the variability in the data collected and does not identify individual plants by name.

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BACKGROUND AND APPROACH

With the codification of the 10 CFR 61 rule in 1983, the NRC mandated a low-level waste classification system based on the concentrations of a specific list of long-lived radionuclides. Three classes of waste were established; A, B, and C. Class A has a lower concentration of the controlling radionuclides and accordingly has the minimum protection requirements. Class B has moderate concentrations of the controlling radionuclides and protection requirements that include those provided for Class A waste plus the additional requirement for an intruder barrier such as a high-integrity container. Class C waste had the highest concentrations of the controlling radionuclides and had protection requirements that include those of Class B plus the additional intruder barrier of deeper disposal or a physical intruder barrier built into the disposal facility.

The performance objectives established for a low-level disposal facility in 10 CFR 61 included the following[2]:

1. The protection of the general population from releases of radioactivity and the maintaining of any releases as low as is reasonably achievable as required by 10CFR61.41
2. Protection of individual from inadvertent intrusion as required for certain waste classes that are identified and verified by the applicant's inspection procedures as required by 10 CFR 61.42
3. Protection of individuals during operations as determined by a comparison of exposures against 10 CFR 20 as it applies to occupational exposures and as required be 10 CF 61.43
4. Stability of the disposal site after closure as ensured by meeting the minimum waste form and stability requirements of 10 CFR 61.56

Ultimately only the second performance objective relates to the waste classification requirements. This is because the limits themselves were defined on the basis of the intruder scenarios. The remaining objectives principally have to do with the disposal facility operations and inventory control of long-lived radionuclides for groundwater protection.

The approach of classifying waste on an IBV basis as opposed to a container basis is being proposed in adherence to the characteristics and features of the fundamental pathway dose modeling provided by the NRC in support of the 10 CFR 61 rule. In other words, the average radionuclide concentrations in the Class A disposal trenches will, in compliance with 10 CFR 61, be maintained at or below the concentration limits of Class A low-level waste. *The only departure from current practice is that the classification would be done on an IBV basis instead of a container basis.*

[2] Title 10 United States Code of Federal Regulations, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste, Subpart C

The wording in the 10 CFR 61 rule only refers to "waste" in the classification discussion in the regulations and not to "waste containers". Thus there should be no conflict with the 10 CFR 61 regulations. It seems that there are two issues of concern to the NRC addressed by the current practice of classifying waste on a container basis. The first is that, if the waste has higher concentration such that it would require an intruder barrier, this requirement would be identified at the time of packaging. The second issue relates to monitoring compliance since classifying on a container basis allows the NRC to audit its licensees for compliance with the 10 CFR 61 rule at the licensees' facilities. The proposed approach, however, would address both of these issues. For the first issue if it is known in advance that a collection of resin waste packages will result in average radionuclide concentrations in the disposal trench within the Class A concentration limits, then all of the resin waste included in that collection could be disposed as Class A without reservation relating to additional stabilization. For compliance if an NRC licensee can provide documentation that the average radionuclide concentrations in a IBV of resins is below Class A limits and that the IBV has been shipped as an IBV to a disposal facility then would demonstrate compliance at the generator's site. To ensure full compliance with 10 CFR 61, it would also be incumbent on the disposal site to implement operating procedures that would ensure that the designated IBV of resin waste has been placed in a contiguous fashion in the disposal trench and that no other waste from other generators has been placed in this contiguous volume.

Review of the Bases for the 10 CFR 61 Concentration Limits

The Low-Level Waste Policy Act of 1980 defined low-level waste disposal as a regional responsibility and directed the NRC to promulgate regulatory requirements specifically addressing regional disposal facilities. In response to this direction the NRC promulgated the 10 CFR 61 regulations in 1983. The NRC published a Draft and Final Environmental Impact Statement (NUREG-0783 and NUREG-0945) which describe, among other things, the purpose of the classification system and the bases for the concentration limits provided in Tables 1 and 2 of 10 CFR 61. The classification system was developed by defining a regional disposal model and dividing the sources of low level waste according to the point of generation within the regional model. Disposal methods considered in the DEIS aimed to maximize the amounts of low level waste that could be accommodated according to the practices of the disposal sites operating at that time. More stringent disposal requirements were sparingly applied to minimize the cost impact of the regulations. The classification system defined by the regulation separated waste into three classes based on the concentration of specific long-lived radionuclides. This was done such that wastes with higher activity concentrations would be accommodated in low-level waste facilities by providing greater protective measures, such as: waste form stability (solidification or high-integrity containers) or disposal features (deeper disposal or intruder barriers) or a combination of both.

The NRC rationalized that the only way for humans to come in contact with the radioactivity or be exposed to the radiation from the buried waste was by releases into groundwater and by inadvertent intrusion in the disposal facility. To facilitate the quantitative analyses of the dose impacts as a function of waste concentrations and different protective features, the NRC developed mathematical models to quantify the radiation dose impacts from the different exposure pathways and scenarios. A target dose limit of 500 mrem/yr was established as a maximum permissible exposure from the intrusion events. Then the calculated dose impacts were compared to the dose limit and concentration limits and protective features were applied such that the limit was not exceeded.

The calculated dose impacts were the bases for the numerical concentration limits established in 10 CFR 61 for the three waste classes.

Accordingly, the three waste classes (A,B, and C) and the concentration limits established for these three classes were based on the principle of providing protection to a potential future intruder into the waste after the lifting of any institutional controls (i.e. 100 years) on the disposal facility. The NRC reasoned that, although unlikely, there could be two fundamental scenarios that would involve human intrusion into the waste after the lifting of all access controls on the facility site. These two scenarios were termed the intruder-construction and the intruder-agriculture scenarios

In the intruder-construction scenario, the NRC hypothesized that an individual would build a 200 m^2 (approximately 10m by 20m) house on the disposal site and digs a basement essentially by hand. The basement area intercepting the waste corresponds to an area that would be occupied by approximately 50 liners. The NRC assumed that a 2-meter deep cover would be placed over the waste. The assumed excavation depth for the basement was 3 meters, thus most of the excavation would be in uncontaminated soil. The total volume of the excavated material was estimated by the NRC to be 906 m^3 (~32,000 ft^3) of which approximately 152 m^3 was estimated to be low-level waste. In digging the basement the individual would be exposed to direct gamma radiation from gamma-emitting radionuclides in the waste/soil mixture and to inhalation exposure from the re-suspension of the waste/soil particles during the excavation. In constructing the basement it was assumed that the length of time that the worker would be exposed to the radiation and radioactivity would depend on the waste form. If the waste had no stability features (solidification or high-integrity container) then it was assumed that the waste would be indistinguishable from natural soil and the exposure period would be 500 hours or about 3 months. The NRC in guidance documents has indicated that the stability feature (solidification or container) should have a life of 300 years.

If, on the other hand, the waste had stability features then it was assumed that the worker would recognize that he was excavating in something other than natural soil and cease the construction activities and proceed to determine the past uses of the site. The exposure period for this intruder-discovery event was assumed to only be 6 hours rather than 500 hours. This means that considerably higher concentrations (perhaps as high as a factor of 83) could be accommodated for both Class B and C waste because of the stabilization requirement for these wastes. If the intruder-discovery event is triggered, then it is assumed that the neither the intruder-construction even nor the intruder-agriculture scenario take place.

If the higher activity waste were to be buried at greater depths or buried beneath a layer of lower activity waste, the NRC speculated that the probability of deeper excavations by inadvertent intruders would decrease considerably, probably ruling out basement excavations, but perhaps resulting from sub-basement excavations for high-rise buildings. Although, the quantitative formulation for the hypothetical scenario for a deeper excavation was not developed, instead the NRC simply allowed a factor of 10 increase for the allowable concentrations for all radionuclides for waste buried deeper than 5 meters and a factor 1200 increase in the gamma-emitting radionuclides because of the greater attenuation by the soil above the waste. If an intruder barrier at the disposal facility was to be provided in place of deeper disposal, the NRC requires the barrier to have a life of 500 years.

The intruder-agriculture scenario is, in effect, a continuation of the intruder-construction in that the NRC hypothesized that an individual would live in the house built on the site and raise food plants grown in the contaminated soil from the basement excavation that was spread around the outside of the house. The exposure pathways for this scenario included inhalation of contaminated dust from around the house, ingestion of the food plants from the garden and direct gamma from the waste/soil mixture spread around the house. In the modeling it was assumed that half the food grown in the contaminated soil is consumed by the individual living on the site. Specific times were assumed for the allocation of the individual's time during a year that he is at work, outdoors, gardening, indoors, etc. for exposure duration calculations in the air uptake and the direct gamma pathways.

One important aspect of the pathway modeling is that the radionuclide concentrations in the waste/soil mixture are assumed to be at the average of the total waste/soil volume involved in the excavation. This assumption is made not only for mathematical convenience but also because it is the best representation of the actual exposure conditions. In the intruder-construction scenario where the individual is digging in all parts of the excavation and the re-suspension of the waste/soil particles is also taking place from all portions of the excavation there is a natural averaging. Likewise in the intruder-agriculture scenario, the individual dwells indoors in all portions of the house and outdoors in broad areas and he grows food plants for ingestion where the plant roots will be in soil with relative average radionuclide concentrations by virtue of the spreading of the excavation soil.

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SUMMARY AND CONCLUSIONS

In order to classify more routine nuclear plant resin and filter waste as Class A, it is being proposed that nuclear plant waste be classified on a multi-container basis rather than on an individual container basis in accordance with current practice. This has the effect of raising the average concentrations of the radionuclides in the Class A trench up to, but not exceeding, the Class A concentrations. In addition the increases should not violate the performance objectives of 10 CFR 61. Three areas of concern were identified; (1) Are there any regulatory obstacles to the implementation of this approach? (2) What is the benefit to the nuclear industry? and (3) How would it be implemented and is it practical to implement the approach?

Although the concept is fairly simple, the dose modeling and information contained in the DEIS, FEIS and the UPDATE documents were reviewed to determine if there were any likely regulatory obstacles to such an approach and also to identify any problems or excessive degrees of conservatism in the basic work performed by the NRC in support of 10 CFR 61. In the review of the information in the documents the first potential obstacle was identified. The NRC recognized that the average concentrations in the trench would be much smaller than the allowable concentration limits in 10 CFR 61. This occurs by virtue of mixing high and low activity waste in the trench and since the higher activity can never exceed the limit, by definition the average will always be smaller than the limit. The NRC reckoned that this would be acceptable and that the smaller concentrations, whatever they may be, would represent the ALARA principle. Even though the ALARA level was not quantified nor justified by a rigorous cost/benefit analysis, the implementation of the multi-container classification approach would reduce the ALARA margins. A second related concern was the fact that the NRC had raised the Cs-137 allowable limit by a factor of 20 over that indicated by the dose modeling for the intruder scenarios. This was done to account for the very large range of Cs-137 concentrations observed in the industry data in 1983.

Unfortunately, the factor of 20 means that as the average Cs-137 concentration in the trench resulting from the multi-container classification approaches the 10 CFR 61 allowable limit, the calculated intruder doses would exceed the performance objective of 500 mrem/yr by the same factor of 20. This realization suggested that additional protection should be provided for the Class A waste, over that described in the DEIS, to accommodate the increased Cs-137 concentrations in the trench. It was concluded that deeper disposal (5 meters of cover) or stabilization should be provided even though the waste was classified as Class A.

For the deeper disposal, the NRC allowed a higher allowable concentration by a factor of 10. Unfortunately, the 10 CFR 61 concentration limits in the regulations are based on a cover depth of only 2 meters and there is no corresponding set of concentrations in the regulations for facilities that provide for deeper disposal. Nonetheless, if the sum-of-the-fractions for a volume of waste are near unity using the concentrations in Tables 1 and 2 of 10 CFR 61, the sum-of-the-fractions for a deeper disposal facility would be 0.1. The effect of the deeper disposal is that the factor of 10, in effect, restores the ALARA margin for all of the radionuclides except Cs-137. For Cs-137 the current situation effectively remains unchanged, in that the potential Cs-137 doses at the average concentrations in the trench will approach the target dose of 500 mrem/yr. In the FEIS it was observed by the NRC that the half-life of Cs-137 was relatively short as compared to the other long-lived radionuclides and therefore the higher risk associated with Cs-137 would only be short-term and still within the performance objective. The long-term risks from the other radionuclides would be small.

For a disposal facility with a cover depth of only 2 meters but provides a concrete structure for the placement of the Class A liners (current Barnwell practice), the Cs-137 and Sr-90 doses are reduced significantly by the additional 200 years of decay provided by the assumed concrete life of 300 years. For the very long-lived radionuclides the doses are somewhat higher than the case of deeper disposal but still well below the target dose value of 500 mrem/yr.

The third potential regulatory obstacle relates to the NRC's BTP that provides guidance on the subject of averaging different waste streams within a container for the purposes of classification. It isn't clear that the BTP would be extended to cover averaging within a trench, but there are arguments that suggest that it should not. The first is that the BTP was aimed principally at higher activity discrete items such activated hardware, sealed sources, etc. that could potentially be removed by an intruder who could incur larger doses that those prescribed by the scenarios parameters. The routine nuclear plant resin and filter waste do not fit in this category. The second argument is that averaging for these waste streams is not addressed in the regulations and the averaging should rightfully encompass the volume of the IBV since there is a natural averaging occurring in the conduct of the scenarios that results in average exposures to an intruder. The third argument is that with deeper disposal and the attendant factor of 10 higher concentration limits, the waste is already accorded higher levels of protection that might be achieved by the averaging restrictions in the BTP and therefore the concern with under-protected Class A waste, which was the NRC's concern with averaging, is not an issue.

To examine the impact on the industry of implementing the approach of classifying resins and filter waste on a multi-container basis, four years worth of data were received from plants representing 41 PWR reactor units and 24 BWR reactor units. The data were separated by waste stream and average concentrations were determined for the 10 CFR 61 radionuclides on an industry-wide basis. The average concentrations used to classify the waste using the sum-of-the-fractions calculated from Tables 1 and 2 of 10 CFR 61. It is noted that the sum-of-the-fractions derived from the 10 CFR 61 allowable limits represent a facility with only 2 meters of cover over the waste and that for a facility with 5 meters of cover; the sum-of-the-fractions would be 10 times smaller.

Table 3-1 shows the summary of the sum-of-the-fractions calculated for the industry-wide averages.

Table 3-1
Summary of Classification Results for the Four Waste Streams Sum-of-the-Fractions

Table 1 Sum of the Fractions

	Resins	Filters	Resins & Filters	Resins, Filters & DAW
C-14	0.03	0.19	0.04	0.00
Tc-99	0.05	0.34	0.07	0.08
TRU	0.18	0.05	0.02	0.02
Pu-241	0.01	0.02	0.00	0.00
Cm-242	0.00	0.00	0.00	0.00
Total	**0.27**	**0.59**	**0.13**	**0.10**

Table 2 Sum of the Fractions

	Resins	Filters	Resins & Filters	Resins, Filters & DAW
H-3	0.00	0.00	0.00	0.00
Co-60	0.00	0.01	0.00	0.00
Ni-63	0.31	0.41	0.32	0.32
Sr-90	0.11	0.04	0.10	0.10
Cs-137	0.61	0.21	0.59	0.58
LT5	0.01	0.03	0.00	0.00
Total	**1.05**	**0.70**	**1.02**	**1.00**

These results which are based on the past four years of data suggest that even for a facility with only 2 meters of cover essentially all the nuclear plant resin and filter waste could be classified as Class A. Applying the factor of 10 for the deeper disposal would clearly allow the classification of all of the resin and filter waste as Class A.

The dose models for the intruder-construction and intruder-agriculture scenarios from the DEIS and the UPDATE were re-constructed in an EXCEL spreadsheet and dose impacts were calculated based on the industry-wide average concentrations in the waste streams. The doses reflect the factor of 10 allowed by the NRC for the deeper disposal.

Table 3-2
Intruder Dose Impacts by Radionuclide for All Resin and Filter Class A Waste at the Industry-Wide Average Concentrations in a Deeper Disposal Facility (mrem and mrem/yr)

	DEIS		UPDATE	
	Construction[1]	Agriculture	Construction	Agriculture
Ni-63	31.4[2]	57.6[2]	0.2	0.3
Cs-137	745.9	882.5	571.3	678.8
TRU	0.0[2]	0.2[2]	10.5	4.2
Co-60	0.1	0.1	0.1	0.1
Sr-90	1.5[2]	112.2[2]	0.1	4.8
Pu-241	2.3[2]	0.0[2]	1.1	0.9
Cm-242	0.0[2]	0.0[2]	0.0	0.0

(1) The dose units for the construction scenario are mrem while those for the agriculture scenario are mrem/yr.
(2) These are organ doses not effective whole body doses.

With the exception of Cs-137 the doses are relatively small and the Cs-137 dose is only slightly over the performance objective of 500 mrem/yr. As discussed in Section 6.0, there are two considerations that argue for the acceptability of exceeding the performance objective by a small fraction. The first is that the intruder-construction doses are one-time dose and not annual dose like the intruder-agriculture scenario. Therefore, a 500 mrem dose in the construction scenario presents a significantly smaller risk to an intruder than 500 mrem/yr to the agriculture intruder. This distinction was not recognized in the original establishment of the 10 CFR 61 performance objective. The significantly higher impact associated with the agriculture scenario should present a persuasive argument for a small increase over the performance objective for the construction scenario. The second consideration is that for the deeper disposal, an exposure scenario was not defined in the DEIS nor in the FEIS nor in the UPDATE and accordingly it is very likely that even if an intruder were to excavate to the deeper depths that it would not be to build a house. It then follows that for the deeper disposal, the intruder-agriculture scenario as defined in the DEIS is not applicable. There is likely to be a post-excavation scenario similar to the intruder-agriculture scenario that would be applicable to the deeper disposal. However, it is unlikely that the exposures would be as severe as those hypothesized for the individual living directly on the excavating material.

A second set of calculations was performed to reflect the current practice at Barnwell of placing the Class A inside of concrete structures provided for the purposes of stabilization. This adds an additional 200 years of decay for the relatively short half-lives for Cs-137 and Sr-90, based on the assumption of a 300 year life for the concrete barriers. The dose results for the 2 meter disposal depth and concrete structures for stabilization are shown in Table 3-3.

Table 3-3
Intruder Dose Impacts by Radionuclide for All Resin and Filter Class A Waste at the Industry-Wide Average Concentrations in Concrete Structures (mrem and mrem/yr)

	DEIS		UPDATE	
	Construction[1]	Agriculture	Construction	Agriculture
Ni-63	69.5[2]	127.7	0.4	0.6
Cs-137	75.7	89.6	58.0	68.9
TRU	0.0[2]	2.3	104.6	41.8
Co-60	0.0	0.0	0.0	0.0
Sr-90	0.1[2]	9.6	0.0	0.4
Pu-241	0.0[2]	0.0	0.0	0.0
Cm-242	0.0[2]	0.0	0.0	0.0

(1) The dose units for the construction scenario are mrem while those for the agriculture scenario are mrem/yr.
(2) These are organ doses not effective whole body doses.

By virtue of the extra 200 years decay time assumed for the stability of the concrete structure, the Cs-137 and Sr-90 will have decayed significantly and thereby reducing the dose impacts significantly.

The wording in the 10 CFR 61 rule only refers to “waste” in the classification discussion in the regulations and not to “waste containers”. Thus there should be no conflict with the 10 CFR 61 regulations. It seems that there are two reasons for the current practice of classifying waste on a container basis. The first is that, if the waste has higher concentration such that it would require an intruder barrier, this requirement would be identified at the time of packaging. The second reason could be to facilitate NRC’s ability to monitor compliance since it allows the NRC to audit its licensees for compliance with the 10 CFR 61 rule at the licensees’ facilities. The proposed approach, however, would address both of these issues. For the first issue if it is known in advance that the resin waste that is to be packaged will, when blended with other resin and filter packages, result in average radionuclide concentrations in the IBV and in the disposal trench that are within the Class A concentration limits, then all of the resin waste could be packaged as Class A without reservation relating to additional stabilization. For compliance if an NRC licensee can provide documentation that the average radionuclide concentrations in a IBV of resins is below Class A limits and that the IBV has been shipped as a IBV to a disposal facility then would demonstrate compliance at the generator’s site. To ensure full compliance with 10 CFR 61, it would also be incumbent on the disposal site to implement operating procedures that would ensure that the designated IBV of resin waste has been placed in a contiguous fashion in the disposal trench and that no other waste from other generators has been placed in this contiguous volume.

4 TECHNICAL ASSESSMENT OF DOSE IMPACTS

The proposal to classify low-level power plant waste on a multi-package basis to include higher activity wastes will increase the average concentrations in a disposal facility up closer to the Class A concentration limits. Although it is proposed that the disposal of power plant process waste be in compliance with the Class A concentrations limits in the disposal cell, it was concluded that it would be prudent to perform a technical assessment of the potential dose impacts to ensure that there were no unforeseen problems with the proposed classification approach. In addition, a current assessment of the dose impacts would identify the degree, if any, of conservatism in the original NRC dose impact methodology and assess the impact of more current dose assessment methodologies that have been implemented since the original NRC work completed in 1983 as described in the DEIS. Lastly, the dose assessment will also provide a measure of the impact of current disposal practices and waste characteristics that may be different from those used in the original analysis in 1983.

To perform the technical assessment of the dose impacts, four sources of information were used: (1) the DEIS, (2) the FEIS, (3) the "Update of Part 61 Impacts Analysis Methodology, NUREG-4370" (UPDATE) published by the NRC in 1986 and (4) the updated IMPACTS computer code package described in NUREG-4370. The DEIS was generated to support the 10 CFR 61 rulemaking and includes relatively detailed descriptions of the dose modeling used to assess the dose impacts of the rule. The FEIS presents a summary of the NRC policies and considerations used as a basis for the rule and the responses to public comment on the rule. The FEIS does not include any technical descriptions of the dose modeling, but rather refers readers back to the DEIS. It should be noted that the original IMPACTS computer code package developed along with the DEIS and used for the calculations in the DEIS was never made available to the public by the NRC. When the NRC published the UPDATE report in 1986 they also made available the updated IMPACTS computer code package for public use. It is important to note that the UPDATE was never subjected to public review or comment and, accordingly, its standing within the NRC is not known, except that they believed that it was adequate for publication. This is also the same situation with the updated IMPACTS computer code package, in that QA documentation has never been produced validating the coding of the program. A QA effort to validate the update IMPACTS code is beyond the scope of this effort, however, a comparison of the computer results with re-creations of the dose models in EXCEL spreadsheets shows that the coding reasonably reflects the descriptions in the UPDATE document.

The first step in the technical assessment of the dose impacts was the re-construction of the mathematical models for the intruder-construction and intruder-agriculture doses presented in the DEIS and the UPDATE in an EXCEL spreadsheet based on the descriptions provided in the respective documents. The basic form of the intruder-construction scenario dose equation is given in the following figure extracted from the EXCEL spreadsheet:

Table 4-1
Intruder-Construction Dose Equation

$H = \sum (f_o\, f_d\, f_w\, f_s)_{air}\, C_w$ PDCF-2 + $\sum(f_o\, f_d\, f_w\, f_s)_{DG}\, C_w$ PDCF-5

Where:

PDCF-2 = pathway dose conversion factor for acute air uptake pathway

PDCF-5 = pathway dose conversion factor for direct gamma pathway

H = is the dose in mrem for the event and includes 50 year commitment for the inhalation pathway

f_o = time delay factor = exp (-λt)

f_d = site design and operation factor = 0.75 for a stacked arrangement

f_d = site design and operation factor = 0.075 if waste is layered

f_d = site design and operation factor = 0.075 x 1/1200 for direct gamma if waste is layered

f_w = waste form and package factor = 1

f_s = site selection factor = 0.057 for direct gamma pathway (500 hrs / 8760 hrs per year)

= 0.057 x T_{sa} for air pathways

Where: The value for T_{sa} differs between regions of the country.

$T_{sa} = (T_{sa})_0 \times (10/v)\ (s/30) \times (50/PE)^2$

and: $(T_{sa})_0$ = 2.53 E-10

Regional Parameters for: v= average wind speed at the site

s = silt content of the site soils

PE = precipitation-evaporation index for the site

Region	Northeast	Southeast	Midwestern	Southwest
v	4.61	3.61	5.3	6.67
s	65	50	85	65
PE	136	91	93	21
$(Tsa)_0$	2.53E-10	2.53E-10	2.53E-10	2.53E-10
(T_{sa}) =	1.61E-10	3.53E-10	3.91E-10	4.66E-09

Table 4-2 presents the DEIS pathway dose conversion factors (PCDFs) for the radionuclides of Ni-63, Cs-137, TRU, Sr-90 and Co-60 in units of mrem/yr per unit concentration in the biota.

Table 4-2
DEIS PDCFs for Some of the 10 CFR 61 Radionuclides. Units Are in mrem/yr per Unit Concentration in the biota and mSv/yr in Parentheses.

PDCFs	Ni-63[1]	Cs-137	TRU	Co-60	Sr-90
2	3.15E+12(3.2E+10)	1.40E+12(1.4E+10)	4.81E+15(4.8E+13)	1.24E+11(1.2E+09)	2.23E+14(2.2E+12)
3	1.00E+13(1.0E+11)	2.12E+12(2.1E+10)	4.85E+13(4.9E+11)	3.70E+11(3.7E+09)	6.21E+14(6.2E+12)
4	2.95E+05(3.0E+03)	7.90E+04(7.9E+02)	5.23E+04(5.2E+02)	5.27E+03(5.3E+01)	1.53E+07(1.5E+05)
5	0.00E+00(0.0E+00)	3.50E+06(3.5E+04)	9.39E+01(9.4E-01)	1.54E+07(1.5E+05)	3.06E+04(3.1E+02)

(1) The shaded PDCFs are the dose conversion factors for organ doses (bone and lung) and the un-shaded PDCFs are total body doses.

The above values were plugged into the dose equation shown at the top of Table 4-1 along with assumed waste concentrations equal to the Class A concentration limits. The results of the calculation are shown in Table 4-3 for the four regions of the country that were considered in the DEIS. The dose impacts represent the potential doses for a Class A disposal facility with the minimum cover depth of two meters.

Table 4-3
Organ and Whole Body Doses Impacts for Intruder-Construction Scenario With Radionuclide Concentrations at 10 CFR 61 Concentrations Limits (Reconstructed DEIS Model) (Dose rates in mrem/hr corresponding values in mSv/hr in parentheses)

Region	Ni-63[1]	Cs-137	TRU	Co-60	Sr-90
Northeast	34(0.34)	12837(128.37)	247(2.47)	356(3.56)	9(0.09)
Southeast	74(0.74)	12838(128.38)	542(5.42)	356(3.56)	15(0.15)
Midwestern	82(0.82)	12838(128.38)	601(6.01)	356(3.56)	16(0.16)
Southwest	981(9.81)	12860(128.60)	7163(71.63)	356(3.56)	143(1.43)

1. The shaded doses are dose to the bone for radionuclides NI-63 and Sr-90 and to the lungs for TRU.
2. The un-shaded doses are total body exposures.

Because the original IMPACTS computer codes are not available, the direct comparison of the above results with the computer codes results is not possible. Also, it should be noted that the NRC did not present the results of the dose impacts with the waste at the concentration limits, but rather presented the dose results using the limits in combination with the waste volumes and radiological characteristics projected to be in low-level wastes. The original IMPACTS computer codes classified the wastes based on the assigned concentrations limits for A, B and C wastes and then assigned the appropriate dose reduction factors associated with the prescribed protection features associated with the waste classes (e.g. stabilization, deeper disposal, etc.). With the classification and the projected waste characteristics, the average concentrations were less then the assigned concentration limits and the doses met the target limit of 500 mrem/yr. It is concluded that the above dose results are in the expected ranges and that the descriptions of the dose models are generally correct.

The results indicate the NRC's intention to generally limit the dose impact to approximately 500 mrem/yr to the whole body or to any organ. The Cs-137 dose reflects the NRC's increase in the concentration limits for Cs-137 by a factor of 20 based on the observed wide range in Cs-137 concentrations in waste and the very small average concentration of Cs-137 in waste. In reviewing the dose impacts from the intruder-construction, two major difficulties come to mind. The first is that although the NRC acknowledged that the intruder-construction dose was an acute dose (one-time, short duration) as compared to the intruder-agriculture doses which were considered chronic in that they could conceivably occur every year for many years, depending on the time that an individual lives on the site, they did not establish a separate, higher dose limit for the intruder-construction scenario to reflect the difference in risk between a one-time dose equal in magnitude to a multi-year dose. The second difficulty, and one that was mentioned by several commenters on the proposed rule, is the establishment of an organ dose limit equal to the whole body dose limit. Several commenters suggested that the NRC should use an "effective dose equivalent" by the use of ICRP-26 organ risk weighting factors. At the time of the rulemaking, the NRC stated that they had not yet accepted the ICRP weighting factors, but did calculate lower cancer risks for the 500 mrem/yr organ dose as compared to the 500 mrem/yr whole body dose. The concentration limits for radionuclides that deliver organ doses were not changed to correspond to the lower organ risks.

In the UPDATE the NRC did present the effective dose equivalent whole body dose in addition to the organ doses. In the UPDATE, the dose models for the intruder-construction scenario are essentially identical to the models presented in the DEIS, with the exception of the waste emplacement efficiency factor where a small change was made. The other changes were to the PDCFs, which included the organ dose weighting factors and corrections to the fundamental dose factors in the pathway analyses.

Table 4-4 presents the UPDATE pathway dose conversion factors (PCDFs) for the radionuclides of N-63, Cs-137, TRU, Sr-90 and Co-60 in units of mrem/yr per unit concentration in the biota.

Table 4-4
UPDATE PDCFs for Some of the 10 CFR 61 Radionuclides Units Are in mrem/yr per Unit Concentration in the biota[1] and mSv/yr in Parentheses.

Ni-63	Cs-137	TRU	Co-60	Sr-90
2.5E+10(2.5E+08)	4.7E+11(4.7E+09)	4.6E+15(4.6E+13)	2.2E+12(2.2E+10)	1.2E+13(1.2E+11)
6.7E+10(6.7E+08)	8.5E+12(8.5E+10)	4.6E+15(4.6E+13)	4.1E+12(4.1E+10)	1.3E+13(1.3E+11)
1.5E+03(1.5E+01)	6.8E+04(6.8E+02)	1.1E+04(1.1E+02)	2.4E+04(2.4E+02)	8.1E+05(8.1E+03)
0.0E+00(0.0E+00)	3.3E+06(3.3E+04)	5.6E+01(5.6E-01)	1.5E+07(1.5E+05)	1.9E-01(1.9E-03)

(1) The PDCFs are the ICRP dose equivalent whole body dose conversion factors.

The UPDATE models were re-constructed in an EXCEL spreadsheet along with the UPDATE PDCFs. The dose impact results are given in Table 4-5.

Table 4-5
Effective Whole Body Doses Impacts for Intruder-Construction Scenario From Update Models With Radionuclide Concentrations at 10 CFR 61 Concentration Limits. Units in mrem/hr (mSv/hr)

Region	Ni-63	Cs-137	TRU	Co-60	Sr-90
Northeast	0(0)	9844(98.44)	193(1.93)	282(2.82)	0(0)
Southeast	0(0)	9844(98.44)	422(4.22)	282(2.82)	0(0)
Midwestern	1(0.01)	9844(98.44)	527(5.27)	282(2.82)	1(0.01)
Southwest	6(0.06)	9850(98.5)	5539(55.39)	282(2.82)	6(0.06)

Comparing the DEIS dose results for the intruder-construction presented in Table 4-2 shows small differences in the Cs-137, TRU and Co-60 doses, but significant differences in the Ni-63 and Sr-90 doses. This is due to the organ weighting factors and some changes in the uptake modeling. The UPDATE results indicate that the Ni-63 and Sr-90 concentration limits in 10 CFR 61 are too low by orders of magnitude and as a practicable matter would not contribute to the classification of nuclear plant low-level waste. As a check on the above calculations the Update IMPACTS computer codes were used to calculate the dose impacts for a Southwest site. Table 4-6 shows the comparison.

Table 4-6
Comparison of Spreadsheet Models and Updated IMPACTS Doses Impacts for Intruder-Construction Scenario With Radionuclide Concentrations at 10 CFR 61 Concentration Limits (mrem whole body dose or mSv in parentheses)

Region	Ni-63	Cs-137	TRU	Co-60	Sr-90
Southwest-EXCEL Models	6(0.06)	9850 (98.5)	5539 (55.39)	282 (2.82)	6 (0.06)
Southwest-Updated IMPACTS	5(0.05)	10700 (107)	3620 (36.2)	339 (3.39)	0.9 (0.009)

Although there are slight differences between the models re-created in an EXCEL spreadsheet and the Updated Impacts, the dose impact results are similar. Because the differences between the computer code and the spreadsheet calculations are small, the differences were not further investigated. Also, the investigation would require a rigorous verification of the computer code which was considered beyond the scope of this effort.

Similar to the exercise described above for the intruder-construction scenario, the dose models from the DEIS and the UPDATE were re-constructed in an EXCEL spreadsheet for the intruder-agriculture scenario. The basic form of the intruder-agriculture scenario dose equation is given in the following figure extracted from the EXCEL spreadsheet:

The form of the intruder-agriculture scenario dose equation is given by:

$H = \sum (f_o f_d f_w f_s)_{air} C_w$ PDCF-3 + $\sum (f_o f_d f_w f_s)_{food} C_w$ PDCF-4 + $\sum(f_o f_d f_w f_s)_{DG} C_w$ PDCF-5

Where: f_o = time delay factor = exp (-λt) the same as the intruder-construction scenario

f_d = site design and operation factor = 0.75 x 0.25 = 0.188 for a stacked arrangement

f_d = site design and operation factor = 0.075 x 0.25 = 0.0188 for a stacked and layered arrangement

f_w = waste form and package factor = 1 for direct gamma and air uptake pathways

= M_0 x t_c x Mult(I6,I7,IS) x 10^{1-I9} for food uptake pathways

t_c = water contact time, assumed to be unity for intruder scenarios

= M_0

Where: M_0 = radionuclide-specific leach fraction

The values in this table were extracted from Table G.14 Appendix G of DEIS NUREG 0782, page G-71

Element		M_0
Nickel		1.48E-02
Cesium		1.62E-04
Strontium		9.86E-03
Plutonium		4.67E-04

f_w = waste form and package factor = M_0 x t_c where tc =1

Ni-63	Cs-137	TRU	Co-60	Sr-90
1.48E-02	1.62E-04	4.67E-04	1.48E-02	9.86E-03

The T_{sa} values for the intruder-agriculture scenario are derived from the intruder-construction scenario by multiplying by a factor of 1.58 to account for the amount of time the site dweller is onsite, indoors, outdoors, etc. The PDCFs for the intruder-agriculture scenario are given in Table 4-1. The above values were plugged into the dose equation shown at the top of Table 4-2 along with assumed waste concentrations equal to the Class A concentration limits. The results of the calculation are shown in Table 4-7 for the four regions of the country that were considered in the DEIS. The dose impacts represent the potential doses for a Class A disposal facility with the minimum cover depth of two meters.

Table 4-7
Organ and Whole Body Doses Impacts for Intruder-Agriculture Scenario With Radionuclide Concentrations at 10 CFR 61 Concentrations Limits (Reconstructed DEIS Model) (mrem/yr and mSv/yr in parentheses)

Region	Ni-63[1]	Cs-137	TRU	Co-60	Sr-90
Northeast	225(2.25)	15202(152.02)	3(0.03)	422(4.22)	1116(11.16)
Southeast	276(2.76)	15202(152.02)	4(0.04)	422(4.22)	1122(11.22)
Midwestern	286(2.86)	15202(152.02)	5(0.05)	422(4.22)	1123(11.23)
Southwest	1412(14.12)	15215(152.15)	31(0.31)	422(4.22)	1263(12.63)

(1) The shaded doses are dose to the bone for radionuclides NI-63 and Sr-90 and to the lungs for TRU.
(2) The un-shaded doses are total body exposures.

The dose results for the intruder-agriculture scenario are chronic doses and as such they have units of mrem/yr unlike the intruder-construction doses which are a one-time acute dose. The results again indicate the NRC's intention to limit the potential exposures to less than 500 mrem/yr by relying on the fact that the average concentrations in the Class A waste trench will be considerably less than the allowable concentrations. As with the intruder-construction doses, the results are both organ and whole body doses. In the UPDATE the NRC did present the effective dose equivalent whole body dose in addition to the organ doses. In the UPDATE, the dose models for the intruder-agriculture scenario are essentially identical to the models presented in the DEIS. The UPDATE models were re-constructed in an EXCEL spreadsheet along with the UPDATE PDCFs. The dose impact results are given in Table 4-8.

Table 4-8
Effective Whole Body Doses Impacts for Intruder-Agriculture Scenario From Update Models With Radionuclide Concentrations at 10 CFR 61 Concentration Limits (mrem/yr and mSv/yr in parentheses)

Region	Ni-63	Cs-137	TRU	Co-60	Sr-90
Northeast	1(0.01)	11659(116.59)	77(0.77)	334(3.34)	48(0.48)
Southeast	1(0.01)	11661(116.61)	167(1.67)	334(3.34)	48(0.48)
Midwestern	1(0.01)	11661(116.61)	209(2.09)	334(3.34)	48(0.48)
Southwest	7(0.07)	11704(117.04)	2193(21.93)	334(3.34)	50(0.5)

As with the intruder-construction scenario, the Ni-63 and Sr-90 dose results are considerably less than the 500 mrem/yr target dose value, suggesting higher concentration limits in 10 CFR 61. The Cs-137 dose impact reflects the factor of 20 increase that the NRC applied to the allowable concentration limit to account for the observed wide range of Cs-137 concentrations and the relatively small average concentration in the actual waste stream data.

As above with the intruder-construction scenario a check on the EXCEL intruder-agriculture calculations was done using the Updated IMPACTS computer codes for a Southwest site. Table 4-9 shows the comparison.

Table 4-9
Comparison of Spreadsheet Models and Updated IMPACTS Doses Impacts for Intruder-Agriculture Scenario With Radionuclide Concentrations at 10 CFR 61 Concentration Limits (mrem/yr whole body dose and mSv/yr in parentheses)

Region	Ni-63	Cs-137	TRU	Co-60	Sr-90
Southwest-EXCEL Models	7(0.07)	11704(117.04)	2193(21.93)	334(3.34)	50(0.5)
Southwest-Updated IMPACTS	4(0.04)	12700(127)	277(2.77)	401(4.01)	2(0.02)

The differences in the TRU and Sr-90 doses are larger than expected. In review of the UPDATE documentation it was noted that the TRU doses changed because of a new lung model. The reasons for the differences in the Sr-90 doses were not immediately obvious and were not investigated further.

In the DEIS, FEIS and the UPDATE, the NRC indicated that deeper disposal provides greater protection from intruder events by reducing the probability of an intruder digging deep enough to intersect the waste. In the discussions in the UPDATE, the NRC noted that excavations deeper than the 3 meters proposed for the intruder-construction scenario were possible, but they were not likely and that they could probably be for something other than a house (e.g. a high rise). While admitting that there were several ways of handling benefits of deeper disposal, the NRC decided that a factor of 10 reduction in the impacts for disposal depths of 5 meters or greater up to a depth of 10 meters at which point the intruder scenarios would not be applicable. In the DEIS, the NRC indicated that for the direct gamma pathways, the deeper disposal would decrease the impacts by an additional factor of 1/1200 to account for the shielding from the deeper disposal.

One of the difficulties with the NRC's approach is that the factor of 10 reduction is not compatible with the 1/1200 reduction factor for the direct gamma pathways. The factor of 1/1200 implies that there is an undisturbed layer of soil between the intruder and the waste source which is at a greater depth. However, the factor of 10 suggests that the intruder makes contact with the waste, but through dilution, etc. the impacts will be less for the greater depth. In the UPDATE, the factor of 1/1200 is not mentioned perhaps because of the recognized incompatibility.

The second difficulty with the simple application of a factor of 10 to account for deeper disposal is that the exposure scenario is undefined. If the excavation is not for the basement of a house what are the exposure parameters? That is; how many hours are involved? What are the dimensions of the excavation and the resulting dilution factors? And lastly, if the construction of a house is not the goal of the excavation, then should the intruder-agriculture scenario be applicable? If the goal of the deeper excavation is a high rise building then it could be argued that the intruder-agriculture scenario is not applicable, at least not as envisioned, and therefore the factor of 10 would only apply to the intruder-construction scenario.

In examining the deeper disposal scenarios and the factor of 10, it is readily observed that the allowable concentration limits for classification in 10 CFR 61 are based on a minimum depth of 2 meters of cover over the waste. However, the current regulations do not provide for classification on the basis of deeper disposal for generators shipping to a facility that provide deeper disposal.

The NRC recognized that by establishing an upper concentration limit for the disposal of the three classes of waste the average concentration of the waste in the trench would be considerable lower than the limit. This would be true for all classification radionuclides except Cs-137 where the allowable limit was raised by a factor of 20. The NRC rationalized that the difference between the allowable limit and the actual average concentration in the trench is appropriate as an ALARA measure, especially for the long-lived isotopes. It was noted that even though the ALARA measure would not apply to Cs-137, it is relatively short-lived and the dose impacts would still remain below the 500 mrem/yr. The difficulty of claiming advantage from the actual lower average concentrations for ALARA benefits is that the ALARA measure was implemented as a matter of policy without the benefit of the requisite cost-benefit analysis characteristic of ALARA assessments.

The major conclusions from the technical assessment discussed above are as follows: (1) to permit the classification of nuclear plant low-level process waste on a multi-container basis, deeper disposal (approximately 5 meters of cover or layered with lower activity waste) or stabilization of the Class A waste will be required to provide protection, primarily for Cs-137. The dose impacts from all other radionuclides, even with a minimum 2 meter cover, would be significantly less than the 500 mrem/yr, thereby maintaining the ALARA feature, (2) although the 500 mrem/yr performance objective is too low and not appropriate for the intruder-construction scenario, multi-container classification can be achieved and still remain within the performance objective (3) the deeper disposal should preclude the application of the intruder-agriculture scenario.

As a check on the reasonableness of the pathway dose conversion factor for the direct gamma exposure pathway values contained in the DEIS and UPDATE, MicroShield point kernel shielding calculations were performed. In the DEIS and UPDATE, the NRC used a gamma exposure correlation for contaminated soil taken from a HASL document dating back to the mid-1970s. The dose rate values were compared to a MicroShield model for an infinite slab geometry with a uniform concentration of Cs-137 at 1 Ci/m^3. The results of the calculation show that the values in the DEIS and UPDATE overestimate the doses by a factor of approximately 2.8.

5 AVERAGING RULE AND CLASSIFICATION

The NRC issued a Branch Technical Position (BTP) in 1992 on concentration averaging and encapsulation to provide guidance to generators on classification of mixtures of heterogeneous waste types including sealed sources, activated metal components, and cartridge filters in individual packages. The BTP addressed the classification of waste packages since, at least at that time; it was thought that the package was the logical unit volume or weight on which to base the classification. The package, in effect, was defined as the disposal unit for classification even though, neither 10CFR61 nor the earlier NRC Branch Technical Position on Classification explicitly make this claim. The 10 CFR 61 regulations refer only to determining concentrations in waste and classifying waste to assure proper placement in the disposal facility. The concept of classifying waste on a multi-container basis has never been broached nor evaluated by regulatory agencies and, therefore, the regulatory applicability of the averaging guidance in the BTP is unknown.

Although, the NRC rationalized the BTP on the basis that averaging guidance was needed because the distribution of radionuclides may not be “reasonably” homogeneous, “as generated” waste may have been processed, waste may include mixtures of different types of wastes, waste may include components of varying concentration, and the container may be large compared to waste, a definitive statement was not provided on how and what specific additional protection would be provided by implementing the guidance. One of the NRC’s major concerns was with discreet items in waste packages such as sealed sources, activated hardware, etc. The NRC was concerned about the averaging of low activity waste streams with very high activity streams such as discrete sealed sources or activated metals. Such high specific activity material could be mixed with lower activity material and when averaged over the larger volume, be evaluated at a lower classification. Accordingly, the BTP covered mixing of activated materials, sealed sources, mixing of cartridge filters, mixing of contaminated materials, wastes in high integrity containers. It went farther, however, and even included the mixing of homogenous waste streams and solidified and absorbed liquids which are not discrete items.

The BTP places specific limits on the mixing of radioactive materials within a package for the purpose of waste classification. For process wastes, the general rule is that averaged material components within a package, specific activities within the components must be within a factor of 10 of the average specific activity. However, for the intruder scenarios presented in the 10CFR61 EIS as a basis for the rule, the concern with averaging of high and low activity wastes, particularly homogeneous process wastes; to lower the overall classification is not supported by the analyses provided in the DEIS. As discussed in Section 4.0, the hypothetical dose impacts in the intruder scenarios were based on calculations in which it was assumed that the radionuclides in the waste were essentially homogeneous throughout the volume of waste/soil mixture in the disposal trench that is assumed to be intercepted by the intruder.

The NRC developed mathematical models to quantify the radiation dose impacts from the different pathways and scenarios. The calculated dose impacts were the bases for the numerical concentration limits established in 10 CFR 61 for the three waste classes. One important aspect of the pathway modeling is that the radionuclide concentrations in the waste/soil mixture are assumed to be at the average of the total waste/soil volume involved in the excavation. This assumption is made not only for mathematical convenience but also because it is the best representation of the actual exposure conditions. In the intruder-construction scenario where the individual is digging in all parts of the excavation and the re-suspension of the waste/soil particles is also taking place from all portions of the excavation there is a natural averaging. Likewise in the intruder-agriculture scenario, the individual dwells indoors in all portions of the house and outdoors in broad areas and he grows food plants for ingestion where the plant roots will be in soil with relative average radionuclide concentrations by virtue of the spreading of the excavation soil. The intruder scenarios are based on the waste having “soil-like” properties and being indistinguishable from natural soil. The scenarios did not anticipate discrete items, principally fabricated of stainless steel, such as activated hardware and sealed sources retaining their general form and thus inviting close contact by a curious intruder and corresponding high dose rates.

It was argued during the review period for the BTP, that disposal considerations are based on a much larger volume. In particular, disposal criteria are based on the volume associated with the intruder construction scenario. In the intruder construction scenario, it is assumed that an intruder excavates the foundation for a house in an area of the disposal facility. The excavation is made into the “segregated” unstabilized waste trench. This trench is provided only 2 meters of cover. An area of 10m x 20m (2150 ft^2 house) is excavated to a depth of 3 m. Assuming an emplacement efficiency of roughly 0.75, this results in the intruder removing 152 m^3 (~50 100 ft^3 liners) of waste from the trench. During the excavation it is assumed that the intruder is working in the vicinity of the exposed waste. In effect, given the basis for the determination of the disposal concentration limits in 10 CFR 61, The 50 liners would constitute a basic averaging volume. It would be that volume that the intruder protection scenario would apply. Additional discussion of the steps performed and the limiting factors in the analysis of this scenario is provided in Section 4.

It could be argued that in the absence of discreet items, such as those identified above, in routine resins and filter waste, the averaging should be based on the volume involved in the intruder event (i.e., the IBV). A second more compelling argument is that with the deeper disposal or stabilization of Class A waste proposed for the multi-container classification, the additional protection that would be achieved by restricting the volumes over which the averaging is to be done in accordance with the BTP is already provided by the additional depth or stabilization. In other words, the restrictions on averaging specified in the BTP are aimed at reducing the effect of dilution of higher activity waste that may be deemed appropriate for higher classification and greater levels of protection. The 5 meter depth is the depth required for Class C waste and is being proposed for the multi-container classification or stabilization of the Class A waste.

6
INDUSTRY DATA COLLECTION

Shipping data that represent all of the LLW waste packages shipped over the past four years were requested from all US utilities. The objective of the data collection is to develop overall profiles for the routine power plant waste streams, excluding activated hardware, as a basis for developing waste stream profiles. This will allow projections to be made of the overall generation rates of routine waste material in all three 10 CFR 61 waste classes on a plant type and unit basis as well as on an industry basis. The profiles provide the radionuclide characteristics necessary to evaluate waste classification on a multi-container basis across the nuclear power industry. These profiles would be used to determine the magnitude of the benefits of multi-container classification in terms of classifying a larger volume of waste as Class A.

Data were received from 41 nuclear plants including 41 PWR reactor units and 24 BWR reactor units. The bulk of these data were received in the form of spreadsheet tables transferred by WMG from the ACCESS database tables used in their RADMAN computer program. These data were reorganized and transferred to a SQL data table to allow flexible applications of SQL scripts for sorting and retrieval purposes. The final composite SQL table containing the records for all 65 reactor units includes a little over 8500 records representing individual packages or sub-package items. For the remainder of this report "package" or "package record' will be used interchangeably with database record. A screening criterion was applied to extract records for actual shipments only. The criterion used was that there would be a valid shipment number on each package. If a package or sub-package did not have a valid shipment number, the package record was declared non-usable and was removed from the final SQL table. A little over 1500 records were excluded.

As the data were received they were reformatted for compatibility with spreadsheet analysis. Each record set was evaluated to determine the 10CFR61 Class A sum-of-the-fractions (SOFs) for Tables 1 and 2. Data from the spreadsheets from each plant was successively added to the database table including the sum-of-the-fractions columns. An additional column was added to the data set to carry the plant identification. It was later necessary to add a column listing unique shipment numbers formed by the shipment number in the data base appended to a plant identification code. Including the Class A SOFs in the database allows for more targeted sorting on waste class. Sorting can be performed over a range of classification values. Even though some of the packages evaluate to B and C classification, evaluating all of the packages against the Class A limits provides a common denominator

An additional table was added to the database listing plant information. The "plants" table listed all of the plants in the industry along with type, number of units, total megawatts electrical, owner/operator, and a two letter identifier. These data were derived from the Nuclear News, Ninth Annual Reference Issue, March 2007. The Nuclear News listing accounted for 67 PWR units and 33 BWR units – 100 units in total. The response to the survey accounted for a total of

65 units including 41 PWRs and 24 BWRs or 65% of the operating reactors units in the U.S. power industry.

The shipping data collected were for the last four years of operation, from January 2003 through roughly March 2007. The data generated after December 2006 is not used in summaries presented below. Overall the data are expected to reasonably represent future generation patterns. General data and important radionuclides extracted from the shipping records database are shown in Table 6-1.

Table 6-1
Data Summary

Shipment Date
Stream Designation
Package ID
Shipment ID
Waste Volume
Waste Weight
NRC Classification
Principal Nuclides (Curies) Including
H-3
C-14
Co-60
Ni-63
Tc-99
Sr-90
Cs-137
U-235
Pu-238
Pu-239/240
Pu-241
Am-241
Cm-242
Cm-243,244
Calculated Columns
Other TRU (excludes Cm-242 and Pu-241)
Total Gamma with less than 5 years half-life
Part 61 Table 1 Class A SOF
Part 61 Table 2 Class A SOF
Unique Shipment Identifier

Radwaste material types are tracked by the stream numbers specified on the Uniform Manifest, Form 541. These uniform manifest stream numbers are listed in Table 6-2. They are used for tracking waste types in the Manifest Information Management System maintained by the Department of Energy. All waste must be assigned to a particular category for disposal.

The RADMAN™ computer program allows up to three of these numbers to be applied within a given package. Since we are unable to proportion the material to the specified streams from the package records, the first stream designation was treated as the default designation. In many cases it doesn't make any difference since the streams would be combined in our summarization. However, some of the packages listed both resin and cartridge filter content. It is supposed that most often these packages are predominantly resins, the presence of filters in the packages will impact the package totals and reduce the purity of the segregation process.

Table 6-2
Uniform Manifest Waste Stream Categories

Category Number	Generic Description
20	**Charcoal**
21	**Incinerator Ash**
22	**Soil**
23	**Gas**
24	**Oil**
25	**Aqueous Liquid**
26	**Filter Media**
27	**Mechanical Filter**
28	**EPA or State hazardous**
29	**Demolition Rubble**
30	**Cation ion-exchange Media**
31	**Anion Ion-exchange Media**
32	**Mixed Bed Ion-exchange Media**
33	**Contaminated Equipment**
34	**Organic Liquid (except oil)**
35	**Glassware or Labware**
36	**Sealed Sources**
37	**Paint or Plating**
38	**Evaporator Bottoms/Sludges/Concentrates**
39	**Compactable Trash**
40	**Non-compactable Trash**
41	**Animal Carcass**
42	**Biological Material(except Animal Carcass)**
43	**Activated Material**
59	**Other**

For the purposes of the evaluations in this study, the three waste streams of resins, filters and DAW are assumed to include the waste categories shown in Table 6-3. These stream groupings are all generated on a routine basis and for any given plant would make up the bulk of the waste volume generated in any year. In the case of filters and filter media, it appeared that the categorizations were interpreted differently by plant generators (in some cases cartridge filters were listed as 26 and in other cases they were assigned category 27). It is likely that much of what is listed as stream 27 in BWR data sets is actually powdered resin used in reactor water cleanup systems. Overall the filter categories comprised the grouping with the least number of entries, so it was decided to include both streams completely in the category of filters. For the most part verbal stream descriptions provided with the package records were not always sufficiently detailed or complete for assigning a package to a particular stream number.

Activated metals were excluded from the evaluation due to their physical nature (i.e., discrete versus homogeneous) average and their relatively small volume. Within the data collected, activated metals made up only about 0.2% of the volume but contained 85% of the total activity. Long lived radionuclides dominating the classification of activated metals are Ni-63 and Nb-94. Since the waste is generally considered inherently stable, other radionuclides will not factor significantly in intruder exposures. Alternative disposal configurations for activated metals should be the subject of a separate examination.

Table 6-3
Power Plant Principal Waste Stream Groupings for Evaluation

Waste Stream	Description	Included Categories
Resins	Homogeneous (Resins)	20, 30, 31, 32, 38
Filters	Cartridge Filters	26, 27
DAW	Dry Active Waste	39, 40

The three waste streams account for the bulk of the data in the SQL tables. Packages excluded from the grouping include: activated metals, waste oil, contaminated equipment, soil, green is clean, and undesignated material (Uniform Manifest category 59). Overall the 3 waste streams account for 6331 out of the original 8581 records or about ¾ of all of the usable records collected.

Table 6-4 provides a breakdown of the total waste volume by stream type generated by the 65 reactor units over the 4 year time span. Table 6-5 provides a similar breakdown of activity by stream type. Of those records not evaluated in this report, the largest of these streams (in volume) are contaminated soil and contaminated equipment (streams 22 and 33, respectively). The materials included in the three groups evaluated account for about 89% of the total volume and about 98 % of the total activity. Volumes and activities of streams excluded in the evaluation generally represent very low activity material and often material not routinely generated. For example, there tabulated almost 90,000 cu ft of contaminated soil that accounts for less than 1 curie of the total activity. In the larger picture, this volume, if actually disposed in a Class A facility, would result in additional dilution across the facility. It is unlikely that all plants would routinely be shipping contaminated soil or would be a reliable source for it.

Table 6-4
Volumes by Waste Stream Type (Volumes thousands of ft^3, volumes in thousands of m^3 shown in parentheses)

Waste Stream	Volume Included	Volume Excluded
Charcoal	8.25(0.23)	
Soil		89.58(2.54)
Oil		15.65(0.44)
Aqueous Liquid		39.14(1.11)
Filter Media	5.67(0.16)	
Mechanical Filter	13.82(0.39)	
EPA or State hazardous		1.18(0.03)
Demolition Rubble		13.37(0.38)
Cation ion-exchange Media	10.75(0.30)	
Anion Ion-exchange Media	1.53(0.04)	
Mixed Bed Ion-exchange Media	214.41(6.07)	
Contaminated Equipment		138.89(3.93)
Organic Liquid (except oil)		0.3(0.01)
Glassware or Labware		11.44(0.32)
Sealed Sources		5.51(0.16)
Paint or Plating		1.34(0.04)
Evaporator Bottoms/Sludges/Concentrates	11.6(0.33)	
Compactable Trash	2005.58(56.78)	
Non-compactable Trash	433.23(12.27)	
Biological Material(except Animal Carcass)		0.08(0.00)
Other		28.8(0.82)
Totals	2705(76.59)	346(9.80)
Total Waste Volume all Waste Streams	3050(86.35)	

Table 6-5
Activities by Stream Type (Activities in Curies values in TBq shown in parentheses)

Waste Stream Designation	Activity Included	Activity Excluded
Charcoal	256.39(9.49)	
Soil		0.89(0.03)
Oil		296.35(10.96)
Aqueous Liquid		336.27(12.44)
Filter Media	11908.73(440.62)	
Mechanical Filter	4430.49(163.93)	
EPA or State hazardous		0.21(0.01)
Demolition Rubble		0.1(0.00)
Cation ion-exchange Media	2820.8(104.37)	
Anion Ion-exchange Media	34.4(1.27)	
Mixed Bed Ion-exchange Media	58822.36(2176.43)	
Contaminated Equipment		320.53(11.86)
Organic Liquid (except oil)		0.98(0.04)
Glassware or Labware		0.82(0.03)
Sealed Sources		0.84(0.03)
Paint or Plating		0.36(0.01)
Evaporator Bottoms/Sludges/Concentrates	1306.48(48.34)	
Compactable Trash	470.07(17.39)	
Non-compactable Trash	118.71(4.39)	
Biological Material(except Animal Carcass)		0()
Other		542.58(20.08)
Totals	80168(2966.22)	1500(55.50)
Total Activity All Waste Streams	81668(3021.72)	

Low-Level Waste Volumes

The waste characteristic data from the 41 nuclear plants were manipulated in different data sorts to extract and summarize the relevant information. One of the initial sorts was to extract the information on the number of shipments of Class A, B and C made over the four year time span (2003 through 2006) of the data request that was included in the database. The data were sorted by plant type, PWR or BWR and by year for the three waste streams discussed above. The projection for the total nuclear power industry was made by multiplying the summed values by the ratio of 67/41 for the PWR data and 33/24 for the BWR data. Table 6-6 shows the results of the data sort for the number of waste shipments projected for the total nuclear power industry.

Table 6-6
LLW Waste Shipment Summary for the Total Industry (Number of Shipments)

Plant Type	Stream	2003	2004	2005	2006	4-Year Average
PWRs	A	294	312	480	561	412
	B	87	88	74	70	80
	C	33	34	29	28	31
	Totals	**413**	**435**	**583**	**659**	**523**
BWRs	A	586	604	657	623	617
	B	26	43	54	34	39
	C	7	7	12	6	8
	Totals	**619**	**653**	**723**	**663**	**664**
Grand Totals		1032	1088	1307	1321	1187

Table 6-7
Average Annual Number of Shipments per Reactor Unit by Plant Type and Waste Classification

Plant Type	Stream	2003	2004	2005	2006	4-Year Average
PWRs	A	4.4	4.7	7.2	8.4	6.1
	B	1.3	1.3	1.1	1.0	1.2
	C	0.5	0.5	0.4	0.4	0.5
	Totals	**6.2**	**6.5**	**8.7**	**9.8**	**7.8**
BWRs	A	17.8	18.3	19.9	18.9	18.7
	B	0.8	1.3	1.6	1.0	1.2
	C	0.2	0.2	0.4	0.2	0.2
	Totals	**18.8**	**19.8**	**21.9**	**20.1**	**20.1**
Grand Totals		24.9	26.3	30.6	29.9	27.9

The database contains package or sub-package entries that identify the activity content, waste stream designation and volume associated with each package or sub-package. However, because one or more packages or sub-packages may included in a single shipment there is not a one-to-one correspondence between the total number of shipments and the total number of packages or sub-packages. As a consequence, the data sorts to extract the information on the waste volumes were done on the basis of entries. For the purposes of the following summaries, the term package has been substituted for the sub-packages, recognizing that the sub-packages are rolled up into packages and ultimately into shipments.

Table 6-8 summarizes the waste volumes for the three waste streams projected for the total nuclear power industry.

Table 6-8
Summary of Annual Waste Volumes by Waste Stream and Plant Type for Total Industry (ft3 and m^3 in parentheses)

	Stream	2003	2004	2005	2006	4-Year Average
PWR	DAW	283538(8028)	328185(9292)	538173(15237)	691779(19586)	460419(13036)
	Resin	37176(1053)	41857(1185)	30229(856)	38819(1099)	37021(1048)
	Filters	2860(81)	4879(138)	4852(137)	4670(132)	4315(122)
	Totals	323574(9161)	374922(10615)	573255(16230)	735268(20817)	501755(14206)
BWR	DAW	368185(10424)	448071(12686)	509210(14417)	478277(13541)	450936(12767)
	Resin	55213(1563)	45962(1301)	57748(1635)	55477(1571)	53600(1518)
	Filters	2406(68)	4106(116)	4083(116)	3929(111)	3631(103)
	Totals	425804(12056)	498138(14104)	571041(16168)	537683(15223)	508167(14388)

Table 6-9 shows the average annual waste volumes for the three waste streams on a reactor unit basis.

Table 6-9
Summary of Average Annual Volumes per Reactor Unit by Plant Type and Waste Stream (ft^3/yr and m^3/yr in parentheses)

	Stream	2003	2004	2005	2006	4-Year Average
PWR	DAW	4232(120)	4898(139)	8032(227)	10325(292)	6872(195)
	Resin	555(16)	625(18)	451(13)	579(16)	553(16)
	Filters	43(1)	73(2)	72(2)	70(2)	64(2)
	Totals	4829(137)	5596(158)	8556(242)	10974(311)	7489(212)
BWR	DAW	11157(316)	13578(384)	15431(437)	14493(410)	13665(387)
	Resin	1673(47)	1393(39)	1750(50)	1681(48)	1624(46)
	Filters	73(2)	124(4)	124(4)	119(3)	110(3)
	Totals	12903(365)	15095(427)	17304(490)	16293(461)	15399(436)

Table 6-10 gives the projection of the annual waste volumes for the three waste streams by plant type in the three waste classes for the total nuclear power industry.

Table 6-10
Projected Annual Industry Waste Volumes by Plant Type and Waste Class for the Three Waste Streams (Volumes in ft3/yr corresponding volumes in m3/yr shown in parentheses)

Plant Type	Stream	Class A	Class B	Class C
PWRs	DAW	460350 (13041.1)	42 (1.2)	26 (0.7)
	Resin	28866 (817.7)	7210 (204.2)	944 (26.7)
	Filters	2949 (83.5)	214 (6.1)	483 (13.7)
	Totals	492166 (13942.4)	7467 (211.5)	1452 (41.1)
BWRs	DAW	450511 (12762.4)	425 (12.0)	0 (0.0)
	Resin	49316 (1397.1)	4048 (114.7)	236 (6.7)
	Filters	3277 (92.8)	152 (4.3)	202 (5.7)
	Totals	503103 (14252.2)	4625 (131.0)	438 (12.4)
Grand Totals		995,269	995269 (28194.6)	12092 (342.5)

Table 6-11 shows the projection of the annual waste volumes for the three waste classes on a reactor unit basis.

Table 6-11
Project Annual Waste Volumes on a Reactor Unit Basis (Volumes in ft3/yr corresponding volumes in m3/yr shown in parentheses)

Plant Type	Stream	A	B	C
PWR	DAW	6871 (194.6)	1 (0.0)	0 (0.0)
	Resin	431 (12.2)	108 (3.1)	14 (0.4)
	Filters	44 (1.2)	3 (0.1)	7 (0.2)
	Totals	7346 (208.1)	111 (3.1)	22 (0.6)
BWR	DAW	13652 (386.7)	13 (0.4)	0 (0.0)
	Resin	1494 (42.3)	123 (3.5)	7 (0.2)
	Filters	99 (2.8)	5 (0.1)	6 (0.2)
	Totals	15246 (431.9)	140 (4.0)	13 (0.4)

Radiological Characteristics

As discussed above, the data on the 8500 packages were sorted into the three waste types of; resins, filters and DAW by reactor type. The data on each package included the radiological information in the form of total curies of the reported radionuclides in each package. The curies of radionuclide were summed over all packages in a waste type to yield the total curies in a waste type and by reactor type. This was then divided by four to get the curies on an annual basis. The BWR value was multiplied by the ratio of 33/24 and the PWR value by 67/41 to project the curies to the total nuclear power industry. The resulting annual total curies in resin waste of the reported radionuclides by reactor type are shown in Table 6-12. This process is repeated for each of the major stream types.

Resins – Radiological Characteristics

Table 6-12
Projected Annual Curies of Individual Radionuclides in Resin Waste by Reactor Type for the Total Industry (Values in Curies corresponding values in TBq are shown in parentheses)

Radionuclide	BWR	PWR	Total
H-3	1.98E+01 (7.3E-01)	5.50E+01 (2.0E+00)	7.48E+01 (2.8E+00)
C-14	2.60E+01 (9.6E-01)	3.70E+01 (1.4E+00)	6.30E+01 (2.3E+00)
Cr-51	1.33E+02 (4.9E+00)	2.93E+00 (1.1E-01)	1.36E+02 (5.0E+00)
Mn-54	1.23E+03 (4.6E+01)	2.33E+02 (8.6E+00)	1.46E+03 (5.4E+01)
Fe-55	1.08E+04 (4.0E+02)	1.50E+03 (5.6E+01)	1.23E+04 (4.6E+02)
Fe-59	1.98E+01 (7.3E-01)	1.18E+00 (4.4E-02)	2.10E+01 (7.8E-01)
Co-57	2.85E-01 (1.1E-02)	2.55E+01 (9.4E-01)	2.58E+01 (9.5E-01)
Co-58	1.01E+02 (3.7E+00)	1.24E+03 (4.6E+01)	1.34E+03 (5.0E+01)
Co-60	4.22E+03 (1.6E+02)	8.46E+02 (3.1E+01)	5.07E+03 (1.9E+02)
Ni-59	8.04E+00 (3.0E-01)	1.16E+01 (4.3E-01)	1.96E+01 (7.3E-01)
Ni-63	1.63E+02 (6.0E+00)	2.98E+03 (1.1E+02)	3.14E+03 (1.2E+02)
Zn-65	5.43E+02 (2.0E+01)	1.09E+00 (4.0E-02)	5.44E+02 (2.0E+01)
Sr-90	6.20E+00 (2.3E-01)	6.40E+00 (2.4E-01)	1.26E+01 (4.7E-01)
Zr-95	3.76E+00 (1.4E-01)	2.76E+00 (1.0E-01)	6.52E+00 (2.4E-01)
Nb-94	6.45E-04 (2.4E-05)	1.31E-02 (4.8E-04)	1.38E-02 (5.1E-04)
Tc-99	2.19E+00 (8.1E-02)	2.34E+00 (8.7E-02)	4.52E+00 (1.7E-01)
Ag-110m	0.00E+00 (0.0E+00)	0.00E+00 (0.0E+00)	0.00E+00 (0.0E+00)
Sb-125	1.14E+01 (4.2E-01)	2.69E+00 (1.0E-01)	1.41E+01 (5.2E-01)
Cs-134	6.83E+00 (2.5E-01)	6.51E+01 (2.4E+00)	7.19E+01 (2.7E+00)
Cs-137	4.23E+01 (1.6E+00)	8.51E+02 (3.1E+01)	8.94E+02 (3.3E+01)
Ce-144	3.89E+02 (1.4E+01)	1.37E+03 (5.1E+01)	1.76E+03 (6.5E+01)
Pu-238	3.09E+01 (1.1E+00)	2.00E+01 (7.4E-01)	5.09E+01 (1.9E+00)
Pu-239/240	0.00E+00 (0.0E+00)	1.25E-04 (4.6E-06)	1.25E-04 (4.6E-06)
Pu-241	6.93E-02 (2.6E-03)	5.17E-02 (1.9E-03)	1.21E-01 (4.5E-03)
Am-241	1.14E-01 (4.2E-03)	1.86E-02 (6.9E-04)	1.33E-01 (4.9E-03)
Cm-242	3.05E+00 (1.1E-01)	2.39E+00 (8.8E-02)	5.44E+00 (2.0E-01)
Cm-243	9.87E-02 (3.7E-03)	3.09E-02 (1.1E-03)	1.30E-01 (4.8E-03)
Cm-244	4.69E-02 (1.7E-03)	2.67E-02 (9.9E-04)	7.36E-02 (2.7E-03)
Total	3.06E+04 (1.1E+03)	1.31E+04 (4.8E+02)	4.38E+04 (1.6E+03)

The values in the above table were divided by 33 and 67 for BWRs and PWRs, respectively to yield the annual curie quantities of the radionuclides in resin waste on a reactor unit basis. The resulting averages are shown in Table 6-13.

Table 6-13
Projected Annual Average Curies of Individual Radionuclides in Resin Waste per Reactor Unit

Radionuclide	BWR	PWR
H-3	5.40E-01 (2.0E-02)	8.00E-01 (3.0E-02)
C-14	7.20E-01 (2.7E-02)	5.50E-01 (2.0E-02)
Cr-51	2.80E+00 (1.0E-01)	4.30E-02 (1.6E-03)
Mn-54	2.50E+01 (9.3E-01)	3.40E+00 (1.3E-01)
Fe-55	2.40E+02 (8.9E+00)	2.20E+01 (8.1E-01)
Fe-59	4.20E-01 (1.6E-02)	1.80E-02 (6.7E-04)
Co-57	7.20E-03 (2.7E-04)	3.70E-01 (1.4E-02)
Co-58	2.40E+00 (8.9E-02)	1.80E+01 (6.7E-01)
Co-60	1.10E+02 (4.1E+00)	1.20E+01 (4.4E-01)
Ni-59	2.40E-01 (8.9E-03)	1.70E-01 (6.3E-03)
Ni-63	4.30E+00 (1.6E-01)	4.30E+01 (1.6E+00)
Zn-65	1.60E+01 (5.9E-01)	1.60E-02 (5.9E-04)
Sr-90	1.80E-01 (6.7E-03)	9.40E-02 (3.5E-03)
Zr-95	2.70E-02 (1.0E-03)	3.60E-02 (1.3E-03)
Nb-94	2.00E-49 (7.4E-51)	5.40E-07 (2.0E-08)
Tc-99	2.00E-05 (7.4E-07)	1.70E-04 (6.3E-06)
Ag-110m	6.30E-02 (2.3E-03)	3.40E-02 (1.3E-03)
Sb-125	3.40E-01 (1.3E-02)	3.30E-02 (1.2E-03)
Cs-134	2.70E-02 (1.0E-03)	9.30E-01 (3.4E-02)
Cs-137	1.30E+00 (4.8E-02)	1.30E+01 (4.8E-01)
Ce-144	1.20E+01 (4.4E-01)	2.00E+01 (7.4E-01)
Pu-238	9.00E-01 (3.3E-02)	2.90E-01 (1.1E-02)
Pu-239/240	2.00E-03 (7.4E-05)	7.30E-04 (2.7E-05)
Pu-241	3.30E-03 (1.2E-04)	2.60E-04 (9.6E-06)
Am-241	7.70E-02 (2.8E-03)	3.40E-02 (1.3E-03)
Cm-242	2.90E-03 (1.1E-04)	4.50E-04 (1.7E-05)
Cm-243	1.40E-03 (5.2E-05)	3.50E-04 (1.3E-05)
Cm-244	1.10E-03 (4.1E-05)	5.90E-04 (2.2E-05)

The average radionuclide distribution for BWR resin waste based on the industry data is given in Figure 6-1.

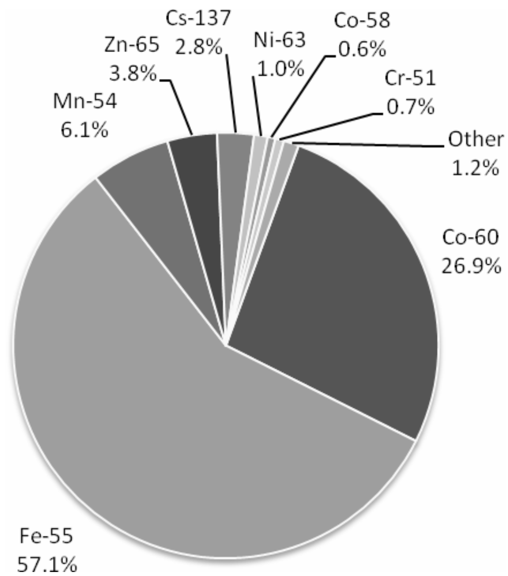

Figure 6-1
Industry Average BWR Resin Radionuclide Distribution

The average radionuclide distribution for PWR resin waste based on the industry data is given in Figure 6-2.

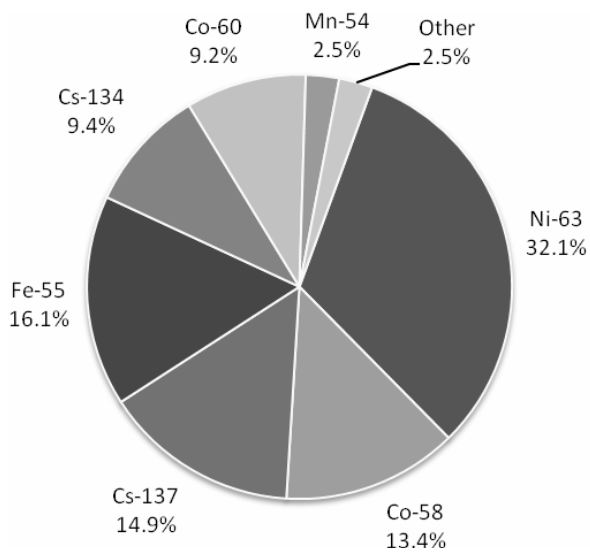

Figure 6-2
Industry Average Radionuclide Distribution for PWR Resins

For the entire resin waste stream the industry average radionuclide distribution is given in Figure 6-3.

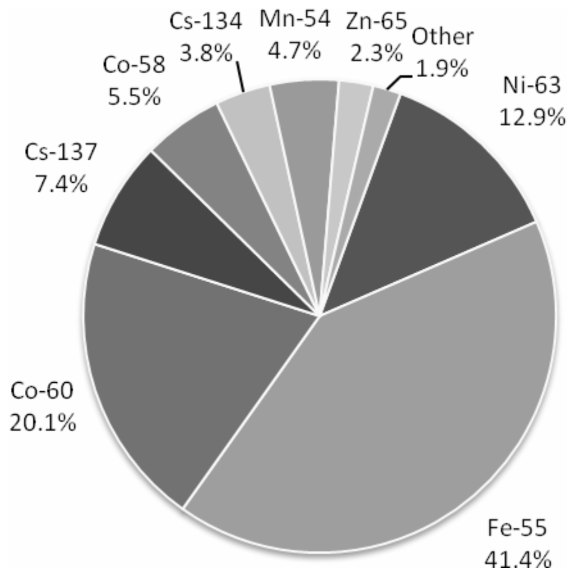

Figure 6-3
Industry Average Radionuclide Distribution for Resins

Filters - Radiological Characteristics

It is obvious from the radionuclide distributions that there is some cross over between the designations of powdered resin filter pre-coats with ion exchange resins – particularly in the BWR classification. It was elected to go forward with this categorization since it corresponds to how the waste would be perceived in the MIMS[3] data base. Packages identified as Filters constituted the smallest grouping of data. In all there were 158 BWR entries and 246 PWR entries. It is recognized that each of the entries does not necessarily represent an individual package. However, based on the various tracking systems employed, it is felt that the annual generation within these streams was representative and on average they would provide an estimate of the annual generation per unit. In a final analysis, much of what is included in these streams could be readily incorporated with the homogeneous streams. Table 6-14 provides an industry-wide estimate of the activity generation from these streams. Table 6-15 provides average activity generation on a unit basis for PWR and BWR plant types.

[3] Manifest Information Management System – http://mims.apps.em.doe.gov

Table 6-14
Projected Annual Curies of Individual Radionuclides in Filter Waste by Reactor Type for the Total Industry (Values in curies corresponding value in TBq shown in parentheses)

Radionuclide	BWR	PWR	Total
H-3	2.15E+00 (8.0E-02)	2.95E+01 (1.1E+00)	3.17E+01 (1.2E+00)
C-14	2.12E+00 (7.8E-02)	2.98E+01 (1.1E+00)	3.20E+01 (1.2E+00)
Cr-51	3.99E+01 (1.5E+00)	2.05E+01 (7.6E-01)	6.04E+01 (2.2E+00)
Mn-54	4.42E+02 (1.6E+01)	2.06E+01 (7.6E-01)	4.62E+02 (1.7E+01)
Fe-55	3.13E+03 (1.2E+02)	5.02E+02 (1.9E+01)	3.63E+03 (1.3E+02)
Fe-59	1.53E+01 (5.7E-01)	1.36E+00 (5.0E-02)	1.66E+01 (6.1E-01)
Co-57	5.28E-02 (2.0E-03)	1.93E+00 (7.1E-02)	1.98E+00 (7.3E-02)
Co-58	2.50E+01 (9.3E-01)	2.84E+02 (1.1E+01)	3.09E+02 (1.1E+01)
Co-60	6.37E+02 (2.4E+01)	1.61E+02 (6.0E+00)	7.98E+02 (3.0E+01)
Ni-59	7.78E-02 (2.9E-03)	8.51E+01 (3.1E+00)	8.52E+01 (3.2E+00)
Ni-63	1.89E+01 (7.0E-01)	2.89E+02 (1.1E+01)	3.08E+02 (1.1E+01)
Zn-65	2.10E+01 (7.8E-01)	1.18E-01 (4.4E-03)	2.11E+01 (7.8E-01)
Sr-90	2.59E-01 (9.6E-03)	8.09E-02 (3.0E-03)	3.40E-01 (1.3E-02)
Zr-95	3.27E+00 (1.2E-01)	4.05E+00 (1.5E-01)	7.32E+00 (2.7E-01)
Nb-94	4.59E-03 (1.7E-04)	8.74E-04 (3.2E-05)	5.47E-03 (2.0E-04)
Tc-99	2.66E-01 (9.8E-03)	7.11E+01 (2.6E+00)	7.14E+01 (2.6E+00)
Ag-110m	1.15E+00 (4.3E-02)	1.63E+00 (6.0E-02)	2.78E+00 (1.0E-01)
Sb-125	6.21E+00 (2.3E-01)	6.03E+00 (2.2E-01)	1.22E+01 (4.5E-01)
Cs-134	5.52E-01 (2.0E-02)	1.08E+01 (4.0E-01)	1.13E+01 (4.2E-01)
Cs-137	1.01E+01 (3.7E-01)	3.50E+01 (1.3E+00)	4.50E+01 (1.7E+00)
Ce-144	2.35E+00 (8.7E-02)	1.12E+00 (4.1E-02)	3.46E+00 (1.3E-01)
Pu-238	6.40E-03 (2.4E-04)	7.47E-03 (2.8E-04)	1.39E-02 (5.1E-04)
Pu-239	1.26E-02 (4.7E-04)	2.31E-03 (8.5E-05)	1.49E-02 (5.5E-04)
Pu-241	3.03E-01 (1.1E-02)	3.63E-01 (1.3E-02)	6.66E-01 (2.5E-02)
Am-241	1.64E-02 (6.1E-04)	4.09E-03 (1.5E-04)	2.05E-02 (7.6E-04)
Cm-242	9.76E-03 (3.6E-04)	6.68E-03 (2.5E-04)	1.64E-02 (6.1E-04)
Cm-243	4.30E-03 (1.6E-04)	5.26E-03 (1.9E-04)	9.57E-03 (3.5E-04)
Cm-244	1.68E-04 (6.2E-06)	4.85E-03 (1.8E-04)	5.02E-03 (1.9E-04)

Table 6-15
Projected Annual Average Curies of Individual Radionuclides in Filter Waste per Reactor Unit (Values in curies corresponding values in TBq shown in parentheses)

Radionuclide	BWR	PWR
Volume	3.10E+00 (1.1E-01)	2.00E+02 (7.4E+00)
Weight	2.10E+06 (7.8E+04)	3.80E+07 (1.4E+06)
H-3	6.90E-02 (2.6E-03)	3.80E-01 (1.4E-02)
C-14	5.10E-02 (1.9E-03)	4.00E-01 (1.5E-02)
Cr-51	1.60E+00 (5.9E-02)	7.10E-02 (2.6E-03)
Mn-54	1.40E+01 (5.2E-01)	1.70E-01 (6.3E-03)
Fe-55	9.70E+01 (3.6E+00)	5.60E+00 (2.1E-01)
Fe-59	4.90E-01 (1.8E-02)	4.60E-03 (1.7E-04)
Co-57	1.60E-03 (5.9E-05)	2.80E-02 (1.0E-03)
Co-58	7.80E-01 (2.9E-02)	4.20E+00 (1.6E-01)
Co-60	1.90E+01 (7.0E-01)	2.30E+00 (8.5E-02)
Ni-59	2.90E-03 (1.1E-04)	1.30E+00 (4.8E-02)
Ni-63	6.60E-01 (2.4E-02)	4.20E+00 (1.6E-01)
Zn-65	6.30E-01 (2.3E-02)	1.80E-03 (6.7E-05)
Sr-90	1.30E-02 (4.8E-04)	1.10E-03 (4.1E-05)
Zr-95	1.00E-01 (3.7E-03)	5.90E-02 (2.2E-03)
Nb-94	1.40E-04 (5.2E-06)	1.30E-05 (4.8E-07)
Tc-99	8.00E-03 (3.0E-04)	8.50E-01 (3.1E-02)
Ag-110m	3.50E-02 (1.3E-03)	1.70E-02 (6.3E-04)
Sb-125	1.90E-01 (7.0E-03)	8.90E-02 (3.3E-03)
Cs-134	1.70E-02 (6.3E-04)	1.60E-01 (5.9E-03)
Cs-137	8.40E-01 (3.1E-02)	5.20E-01 (1.9E-02)
Ce-144	7.30E-02 (2.7E-03)	1.60E-02 (5.9E-04)
Pu-238	2.80E-04 (1.0E-05)	1.10E-04 (4.1E-06)
Pu-239	4.70E-04 (1.7E-05)	3.60E-05 (1.3E-06)
Pu-241	1.10E-02 (4.1E-04)	5.60E-03 (2.1E-04)
Am-241	7.40E-04 (2.7E-05)	6.20E-05 (2.3E-06)
Cm-242	3.00E-04 (1.1E-05)	1.10E-04 (4.1E-06)
Cm-243	1.70E-04 (6.3E-06)	8.20E-05 (3.0E-06)
Cm-244	5.10E-06 (1.9E-07)	7.20E-05 (2.7E-06)

Figure 6-4, Figure 6-5, and Figure 6-6 provide visual representations of the data in Table 6-14 and Table 6-15. Figure 6-4 provides the activity distribution of major radionuclides in BWR filters. Figure 6-5 provides the activity distribution of major radionuclides in PWR filters. Figure 6-6 provides a composite activity distribution for the combined streams. The overall data distributions are consistent with what would be expected from the two plant types. BWR filter activities are more than 70% Fe- 55 with only relative trace amounts of Ni-63 and Co-58. The PWR distribution reflects the extensive use of high nickel alloys in the reactor internals. The industry composite distribution in Figure 6-6, is heavily dominated by the higher overall activity appearing in the BWR record set.

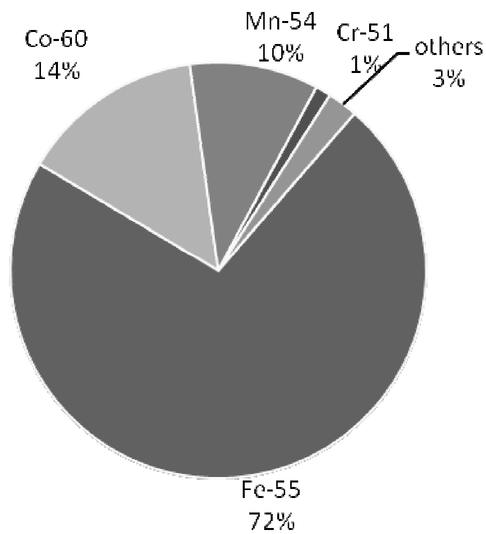

Figure 6-4
Industry Average Radionuclide Distribution for BWR Filters

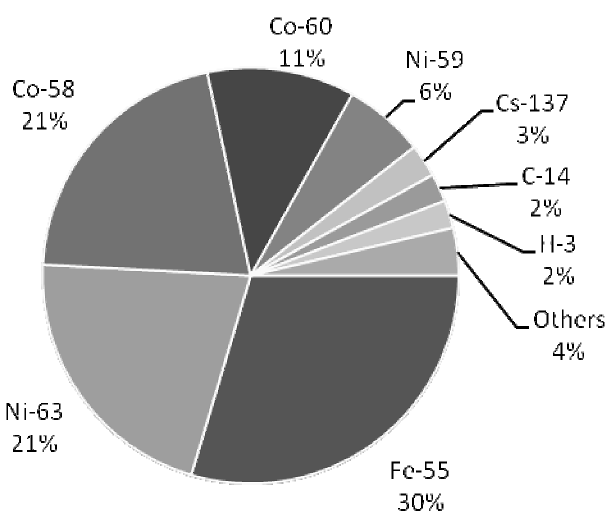

Figure 6-5
Industry Average Radionuclide Distribution for PWR Filters

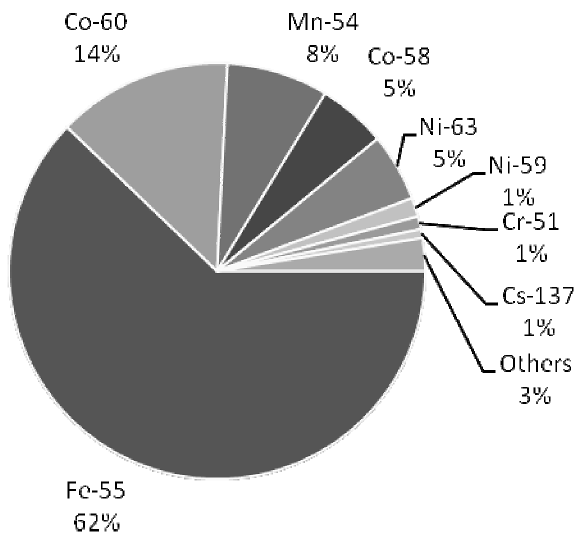

Figure 6-6
Industry Average Radionuclide Distribution for All Filters

DAW - Radiological Characteristics

DAW represents the largest segment of the data basis including 2229 records from PWR plants and 1981 records from BWR power plants. In contrast it doesn't represent the largest activity contribution. DAW accounts for less than 1% of the combined activity of three streams examined.

Table 6-16 provides a industry wide estimate of the activity generation from these streams. Table 6-17 provides average activity generation on a unit basis for PWR and BWR plant types.

Table 6-16
Projected Annual Curies of Individual Radionuclides in DAW Waste by Reactor Type in the Nuclear Power Industry (Values in Curies/year corresponding values in TBq/year shown in parentheses)

Radionuclide	BWR	PWR	Total
H-3	1.10E+00 (4.1E-02)	5.80E+00 (2.1E-01)	7.00E+00 (2.6E-01)
C-14	6.70E-01 (2.5E-02)	2.10E+00 (7.8E-02)	2.70E+00 (1.0E-01)
Cr-51	7.00E+00 (2.6E-01)	1.60E+00 (5.9E-02)	8.60E+00 (3.2E-01)
Mn-54	7.70E+00 (2.8E-01)	9.90E-01 (3.7E-02)	8.70E+00 (3.2E-01)
Fe-55	7.30E+01 (2.7E+00)	2.20E+01 (8.1E-01)	9.50E+01 (3.5E+00)
Fe-59	1.00E+00 (3.7E-02)	8.70E-02 (3.2E-03)	1.10E+00 (4.1E-02)
Co-57	2.00E-04 (7.4E-06)	5.50E-02 (2.0E-03)	5.50E-02 (2.0E-03)
Co-58	1.80E+00 (6.7E-02)	1.10E+01 (4.1E-01)	1.30E+01 (4.8E-01)
Co-60	2.60E+01 (9.6E-01)	1.20E+01 (4.4E-01)	3.80E+01 (1.4E+00)
Ni-59	5.00E-01 (1.9E-02)	1.30E-01 (4.8E-03)	6.30E-01 (2.3E-02)
Ni-63	2.40E+00 (8.9E-02)	1.70E+01 (6.3E-01)	2.00E+01 (7.4E-01)
Zn-65	5.90E+00 (2.2E-01)	7.60E-03 (2.8E-04)	6.00E+00 (2.2E-01)
Sr-90	4.30E-02 (1.6E-03)	5.80E-02 (2.1E-03)	1.00E-01 (3.7E-03)
Zr-95	1.70E-01 (6.3E-03)	7.60E-01 (2.8E-02)	9.20E-01 (3.4E-02)
Zr-97	0.00E+00 (0.0E+00)	1.30E-03 (4.8E-05)	1.30E-03 (4.8E-05)
Nb-94	1.00E-03 (3.7E-05)	2.20E-06 (8.1E-08)	1.00E-03 (3.7E-05)
Tc-99	1.10E+00 (4.1E-02)	2.10E+00 (7.8E-02)	3.20E+00 (1.2E-01)
Ag-110m	2.00E-01 (7.4E-03)	4.10E-02 (1.5E-03)	2.40E-01 (8.9E-03)
Sb-125	1.40E-01 (5.2E-03)	5.30E-01 (2.0E-02)	6.70E-01 (2.5E-02)
Cs-134	5.20E-02 (1.9E-03)	8.80E-01 (3.3E-02)	9.40E-01 (3.5E-02)
Cs-137	1.60E+00 (5.9E-02)	1.10E+01 (4.1E-01)	1.20E+01 (4.4E-01)
Ce-144	2.50E-01 (9.3E-03)	5.40E-01 (2.0E-02)	7.90E-01 (2.9E-02)
Pu-238	1.20E-03 (4.4E-05)	2.50E-03 (9.3E-05)	3.70E-03 (1.4E-04)
Pu-239	1.30E-03 (4.8E-05)	1.30E-03 (4.8E-05)	2.50E-03 (9.3E-05)
Pu-241	4.90E-02 (1.8E-03)	9.40E-02 (3.5E-03)	1.40E-01 (5.2E-03)
Am-241	2.70E-03 (1.0E-04)	4.60E-03 (1.7E-04)	7.30E-03 (2.7E-04)
Cm-242	4.70E-04 (1.7E-05)	9.80E-04 (3.6E-05)	1.50E-03 (5.6E-05)
Cm-243	4.20E-04 (1.6E-05)	2.70E-03 (1.0E-04)	3.10E-03 (1.1E-04)
Cm-244	1.40E-04 (5.2E-06)	1.40E-03 (5.2E-05)	1.60E-03 (5.9E-05)

Table 6-17
Projected Annual Average Curies of Individual Radionuclides in DAW Waste per Reactor Unit (Values in Curies/year corresponding values in TBq/year shown in parentheses)

Radionuclide	BWR	PWR
H-3	3.30E-02 (1.2E-03)	8.80E-02 (3.3E-03)
C-14	2.00E-02 (7.4E-04)	3.10E-02 (1.1E-03)
Cr-51	2.10E-01 (7.8E-03)	2.50E-02 (9.3E-04)
Mn-54	2.30E-01 (8.5E-03)	1.50E-02 (5.6E-04)
Fe-55	2.10E+00 (7.8E-02)	3.40E-01 (1.3E-02)
Fe-59	2.90E-02 (1.1E-03)	1.30E-03 (4.8E-05)
Co-57	5.80E-06 (2.1E-07)	8.30E-04 (3.1E-05)
Co-58	5.40E-02 (2.0E-03)	1.60E-01 (5.9E-03)
Co-60	7.70E-01 (2.8E-02)	1.80E-01 (6.7E-03)
Ni-59	1.50E-02 (5.6E-04)	2.00E-03 (7.4E-05)
Ni-63	7.00E-02 (2.6E-03)	2.60E-01 (9.6E-03)
Zn-65	1.70E-01 (6.3E-03)	1.20E-04 (4.4E-06)
Sr-90	1.30E-03 (4.8E-05)	8.80E-04 (3.3E-05)
Zr-95	4.90E-03 (1.8E-04)	1.10E-02 (4.1E-04)
Zr-97	0.00E+00 (0.0E+00)	1.90E-05 (7.0E-07)
Nb-94	3.10E-05 (1.1E-06)	3.40E-08 (1.3E-09)
Tc-99	3.30E-02 (1.2E-03)	3.10E-02 (1.1E-03)
Ag-110m	5.90E-03 (2.2E-04)	6.10E-04 (2.3E-05)
Sb-125	4.00E-03 (1.5E-04)	8.10E-03 (3.0E-04)
Cs-134	1.50E-03 (5.6E-05)	1.30E-02 (4.8E-04)
Cs-137	4.70E-02 (1.7E-03)	1.60E-01 (5.9E-03)
Ce-144	7.40E-03 (2.7E-04)	8.10E-03 (3.0E-04)
Pu-238	3.50E-05 (1.3E-06)	3.80E-05 (1.4E-06)
Pu-239	3.70E-05 (1.4E-06)	1.90E-05 (7.0E-07)
Pu-241	1.50E-03 (5.6E-05)	1.40E-03 (5.2E-05)
Am-241	7.90E-05 (2.9E-06)	7.00E-05 (2.6E-06)
Cm-242	1.40E-05 (5.2E-07)	1.50E-05 (5.6E-07)
Cm-243	1.20E-05 (4.4E-07)	4.00E-05 (1.5E-06)
Cm-244	4.00E-06 (1.5E-07)	2.10E-05 (7.8E-07)

Figure 6-7, Figure 6-8, and Figure 6-9 provide visual representations of the data in Table 6-16 and Table 6-17. Figure 6-7 provides the activity distribution of major radionuclides in BWR DAW. Figure 6-8 provides the activity distribution of major radionuclides in PWR DAW. Figure 6-9 provides a composite activity distribution for the combined streams. The overall composite distribution is more balanced between the two plant types when contrasted with the comparisons of the individual streams. It also shows a broader mix of radionuclides displaying significant activity.

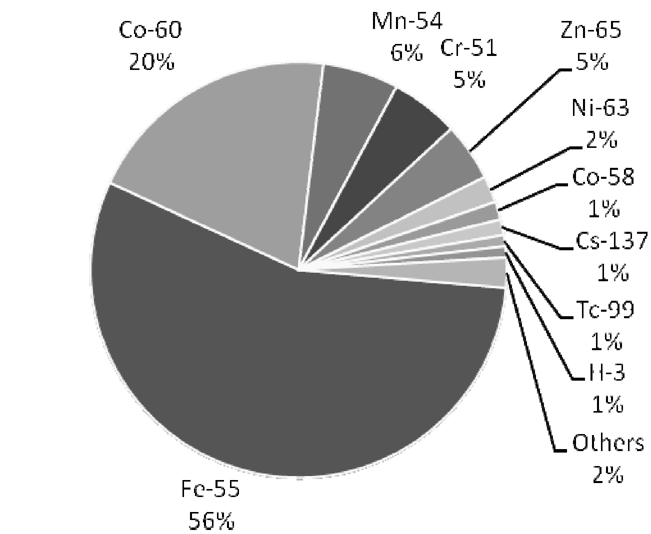

Figure 6-7
Industry Average Radionuclide Distributions for BWR DAW

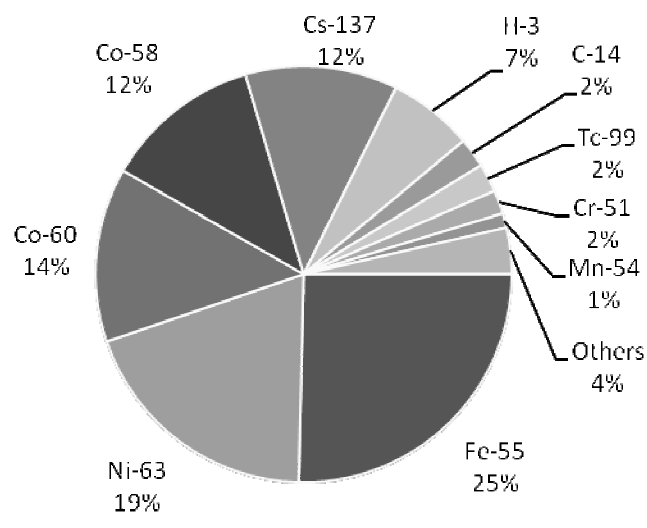

Figure 6-8
Industry Average Radionuclide Distribution for PWR DAW

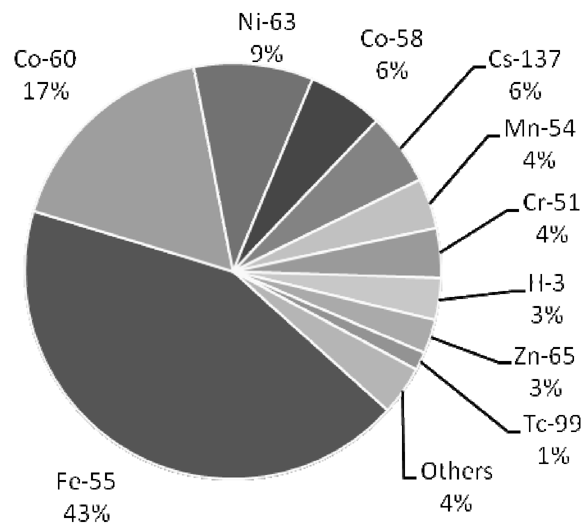

Figure 6-9
Industry Average Radionuclide Distribution for ALL DAW

7
MULTI-CONTAINER CLASSIFICATION ANALYSIS

To estimate the potential benefits of implementing the proposed multi-container approach, in terms of increasing the volume waste classified as Class A waste, the radiological data discussed above in Section 6.0 were used as reasonably representative of future waste generation characteristics. The multi-container approach to classification was applied to two basic sets of cases. For the first set, it was assumed that there would be no restrictions on what can be averaged for the purposes of classification. For the second set of cases, it was assumed that the averaging guidance provided in the BTP would be applied across containers wherein each container in the lot would have an average concentration within a factor of 10 of the lot average. The cases in each set are: all resins, all filters, a combination of all resins and filters and a combination of all resins, filters and DAW.

Without averaging restrictions, the annual average concentrations in the each waste stream across all plants would represent the first set of cases Based on the data described in Section 6.0, the average concentrations of the 10 CFR 61 radionuclides in Tables 1 and 2 were determined for; resins, filters, DAW, resins plus filters and all three wastes streams combined. This average concentration represents the cases where the containers would be classified and shipped to a disposal facility in lots of approximately 50 liners. Table 7-1 shows the industry average concentrations for the four waste streams.

Table 7-1
Industry-wide Average Concentrations in Waste Streams (Ci/m^3 and nCi/g for transuranics) (Values provided for contrast to 10CFR 61 classification corresponding metric values have no comparative value and are not shown)

Radionuclide	Resins	Filters	Resins & Filters	Resins, Filters & DAW
H-3	2.61E-02	1.47E-01	3.45E-02	3.49E-02
C-14	2.19E-02	1.49E-01	3.08E-02	3.05E-02
Co-60	1.77E+00	3.71E+00	1.90E+00	1.87E+00
Ni-63	1.10E+00	1.43E+00	1.12E+00	1.10E+00
Sr-90	4.39E-03	1.58E-03	4.20E-03	4.14E-03
Tc-99	1.58E-03	1.01E-02	2.17E-03	2.30E-03
Cs-137	6.15E-01	2.09E-01	5.86E-01	5.79E-01
TRU	1.77E-01	4.61E-01	1.90E-01	1.90E-01
Pu-241	2.50E+00	6.23E+00	2.68E+00	2.67E+00
Cm-242	3.39E-02	1.54E-01	3.95E-02	4.03E-02
LT5	5.84E+00	2.11E+01	6.90E+00	6.79E+00

Based on the above average concentrations, the waste streams were classified in accordance with 10 CFR 61 using the Table 1 and Table 2 concentration values. This would be the classification for disposal in a facility with only a 2 meter cover on the waste. The results of the classification in terms of the sum-of-the-fractions for Table 1 and Table 2 are given in Table 7-2.

Table 7-2
Summary of Classification Results for the Four Waste Streams Sum-of-the-Fractions

Table 1 Sum of the Fractions

	Resins	Filters	Resins & Filters	Resins, Filters & DAW
C-14	0.03	0.19	0.04	0.00
Tc-99	0.05	0.34	0.07	0.08
TRU	0.18	0.05	0.02	0.02
Pu-241	0.01	0.02	0.00	0.00
Cm-242	0.00	0.00	0.00	0.00
Total	**0.27**	**0.59**	**0.13**	**0.10**

Table 2 Sum of the Fractions

	Resins	Filters	Resins & Filters	Resins, Filters & DAW
H-3	0.00	0.00	0.00	0.00
Co-60	0.00	0.01	0.00	0.00
Ni-63	0.31	0.41	0.32	0.32
Sr-90	0.11	0.04	0.10	0.10
Cs-137	0.61	0.21	0.59	0.58
LT5	0.01	0.03	0.00	0.00
Total	**1.05**	**0.70**	**1.02**	**1.00**

These results effectively indicate that all routine resin and filter waste from nuclear plants could be classified as Class A, if classified on a multi-container basis, even for a disposal facility with a 2 meter cover over the waste. For facilities that have a 5 meter cover or that layer higher activity waste under lower activity waste, the sum-of-the-fractions shown in Table 7-2 would be reduced by a factor of ten, which would result in sum-of-the fractions for Table 2 radionuclides around 0.1 for the classification of all of the routine resin and filter waste. For disposal facilities that provide a concrete structure for the placement of the Class A liners (e.g., current Barnwell practice) and thereby the contribution from Sr-90 and Cs-137 in the sum-of-the-fractions would essentially become zero. For Table 1 radionuclides Tc-99 plays a dominating role in the classification especially for filter waste. However, it is likely that the reported values for Tc-99 are not real values but rather reported MDA values. Some of the containers in the database were showing curie quantities in a single package of 100 curies, which is virtually impossible. For the Table 2 radionuclides the classification is dominated by Cs-137 and Ni-63 with a small contribution from Sr-90. However, following the evaluations performed for the DEIS, the Ni-63 and Sr-90 doses are bone doses and not effective whole body doses. As noted in Section 4, the original DEIS equated organ doses with whole body doses. On a risk basis the allowable concentrations for Ni-63 and Sr-90 should be much higher, leaving Cs-137 as the dominant radionuclide controlling classification and the potential doses to an intruder.

As observed in the calculations described in Section 4.0, with the exception of Cs-137, the small average concentrations in the trench as compared to the allowable limits still preserves the ALARA principal deemed appropriate by the NRC. This can best be understood by examining the potential intruder-agriculture and intruder-construction doses based on the waste having the average concentrations that would result from the multi-container classification. Dose calculations were performed using the dose modeling presented in both DEIS and the UPDATE. The doses were calculated for a facility located in the Southwest region of the country to represent a facility like that at Clive, Utah with the waste at a depth of 5 meters. A second set of calculations were performed for a disposal facility with a 2 meter disposal depth and with placement of the Class A liners inside of a concrete structure (ala Barnwell). Table 7-3 shows the dose results for the deeper disposal facility.

Table 7-3
Intruder Dose Impacts by Radionuclide for All Resin and Filter Class A Waste at the Industry-Wide Average Concentrations in a Deeper Disposal Facility (mrem and mrem/yr)

	DEIS		UPDATE	
	Construction[1] Mrem (mSv)	**Agriculture Mrem/yr (mSv/yr)**	**Construction Mrem (mSv)**	**Agriculture Mrem/yr (mSv/yr)**
Ni-63	31.4(.31)[2]	57.6(0.58)[2]	0.2(0.002)	0.3(.003)
Cs-137	745.9(7.46)	882.5(8.83)	571.3(5.71)	678.8(6.79)
TRU	0.0(0)[2]	0.2(0.002)[2]	10.5(.105)	4.2(0.042)
Co-60	0.1(.001)	0.1(0.001)	0.1(0.001)	0.1(0.001)
Sr-90	1.5(.015)[2]	112.2(1.12)[2]	0.1(0.001)	4.8(0.048)
Pu-241	2.3(.023)[2]	0.0(0)[2]	1.1(0.011)	0.9(0.009)
Cm-242	0.0(0)[2]	0.0(0)[2]	0.0(0)	0.0(0)

(3) The dose units for the construction scenario are mrem (mSv)while those for the agriculture scenario are mrem/yr (mSv/yr)

(4) These are organ doses not effective whole body doses.

With the exception of Cs-137 the doses are relatively small and the Cs-137 dose is only slightly over the performance objective of 500 mrem/yr (5 mSv/yr). As discussed in Section 4.0, there are two considerations that argue for the acceptability of exceeding the performance objective by a small fraction. The first is that the intruder-construction doses are one-time dose and not annual dose like the intruder-agriculture scenario. Therefore, a 500 mrem dose in the construction scenario presents a significantly smaller risk to an intruder than 500 mrem/yr to the agriculture intruder. This distinction was not recognized in the original establishment of the 10 CFR 61 performance objective, should be a persuasive argument for a small increase small increase over the performance objective for the construction scenario. The second consideration is that for the deeper disposal, an exposure scenario was not defined in the DEIS nor in the FEIS nor in the UPDATE and accordingly it is very likely that even if an intruder were to excavate to the deeper depths that it would not be to build a house. It then follows that that for the deeper disposal, the intruder-agriculture scenario as defined in the DEIS is not applicable. There is likely to be a post-excavation scenario similar to the intruder-agriculture scenario that would be applicable to the deeper disposal. However, it is unlikely that the exposures would be as severe as those hypothesized for the individual living directly on the excavating material.

The dose results for the 2 meter disposal depth and concrete structures for stabilization are shown in Table 7-4.

Table 7-4
Intruder Dose Impacts by Radionuclide for All Resin and Filter Class A Waste at the Industry-Wide Average Concentrations in Concrete Structures (mrem and mrem/yr)

	DEIS		UPDATE	
	Construction[1] Mrem(mSv)	Agriculture Mrem/yr (mSv/yr)	Construction Mrem (mSv)	Agriculture Mrem/yr (mSv/yr)
Ni-63	69.5(0.695)[2]	127.7(1.27)	0.4(0.004)	0.6(0.600)
Cs-137	75.7(0.757)	89.6(0.896)	58.0(0.580)	68.9(0.689)
TRU	0.0(0.00)[2]	2.3(0.023)	104.6(1.046)	41.8(0.418)
Co-60	0.0(0.00)	0.0(0.00)	0.0(0.0)	0.0(0.0)
Sr-90	0.1(0.001)[2]	9.6(0.096)	0.0(0.0)	0.4(0.004)
Pu-241	0.0(0.00)[2]	0.0(0.0)	0.0(0.0)	0.0(0.0)
Cm-242	0.0(0.00)[2]	0.0(0.0)	0.0(0.0)	0.0(0.0)

By virtue of the extra 200 years decay time assumed for the stability of the concrete structure, the Cs-137 and Sr-90 will have decayed significantly and thereby reducing the dose impacts significantly. The remaining doses are small and would still satisfy the NRC's ALARA principal.

Resins Classification

Figure 7-1 and Figure 7-2 below show the breakdown of classification controlling radionuclides for PWRs and BWRs, respectively.

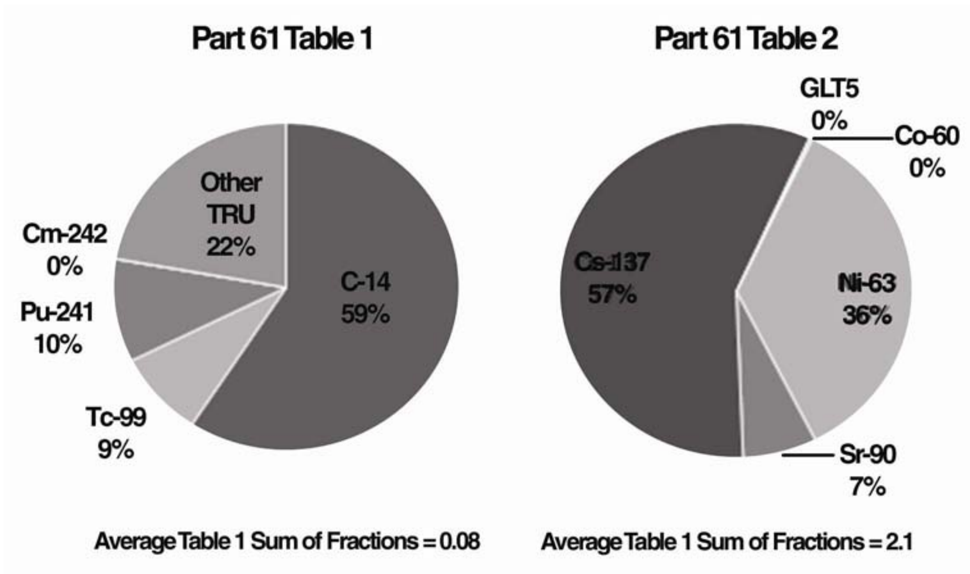

Figure 7-1
Nuclide Contributions to Classification (PWR Resin Streams)

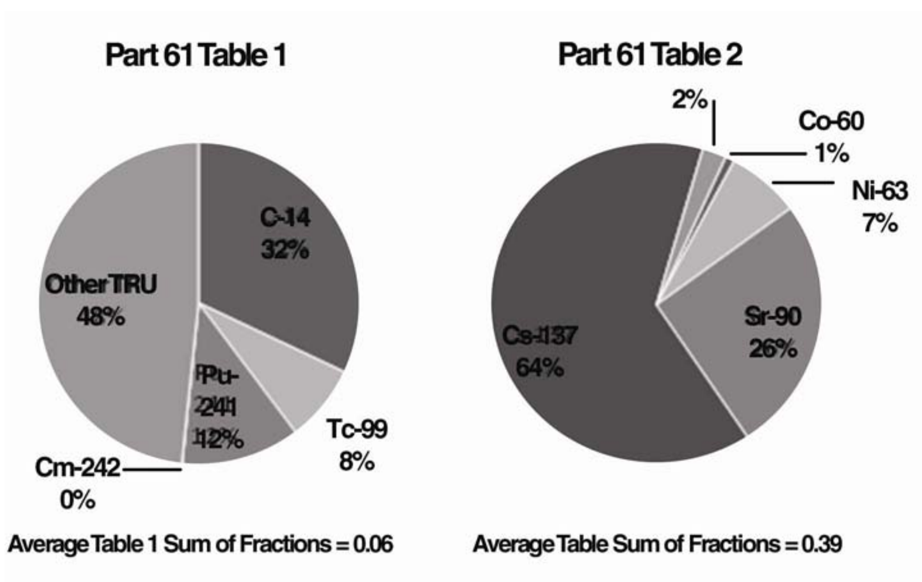

Figure 7-2
Nuclide Contributions to Classification (BWR Resin Streams)

For classification based on Part 61 Table 1, in both the PWR and BWR cases, the overall sum-of- fractions is less than 1/10 of the Table 1 Class A limit. In both the PWR and BWR cases the most prominent Table 1 nuclides are C-14 and transuranics (excluding Pu-241 and Cm-242). C-14 shows a much stronger impact in the PWR case. Closer review of the data base shows that this contribution is due to a few plants.

For classification based on Part 61 Table 2, the average PWR sum of fraction exceeds the Class A limit by a factor of 2.1 while on average the BWR resins are less than the Class A limits. This is expected since the BWRs tend to generate a larger volume of resins per unit while the overall activity releases are comparable. Both PWR and BWR Table 2 fractions are dominated by Cs-137 with the PWRs at 57% and the BWRs at 64%. The next major contributors to classification are Ni-63 at 36% in PWRs and Sr-90 at 26 % in BWRs. While overall, the relative contributions of Ni-63 and Sr-90 will be reduced on blending, Cs-137 will only be mildly impacted and will appear dominant throughout the analysis.

Filters - Classification

Overall filters constitute a much smaller waste stream than the resins. The distribution of Class B and C packages in the filter data set is listed below. While the filter packages are more dominantly Class C, this classification is largely driven by Part 61 Table 1 radionuclides. Radionuclides driving classification for BWRs were dominantly transuranics. For PWRs C-14 and Tc-99 appeared more dominant. Tc-99 appeared particularly problematic in PWRs since in a number of cases extreme values, likely based on detection limits, were causing overstatement of classification. Where the Tc-99 concentrations exceeded class C limits, the concentration was reset to zero to avoid overstating the Tc-99 contribution to overall classification.

Figure 7-3 and Figure 7-4 below show the breakdowns of classification controlling radionuclides for BWRs and PWRs, respectively. Average sum-of-fractions calculated for the entire data sets are provides with each chart for reference.

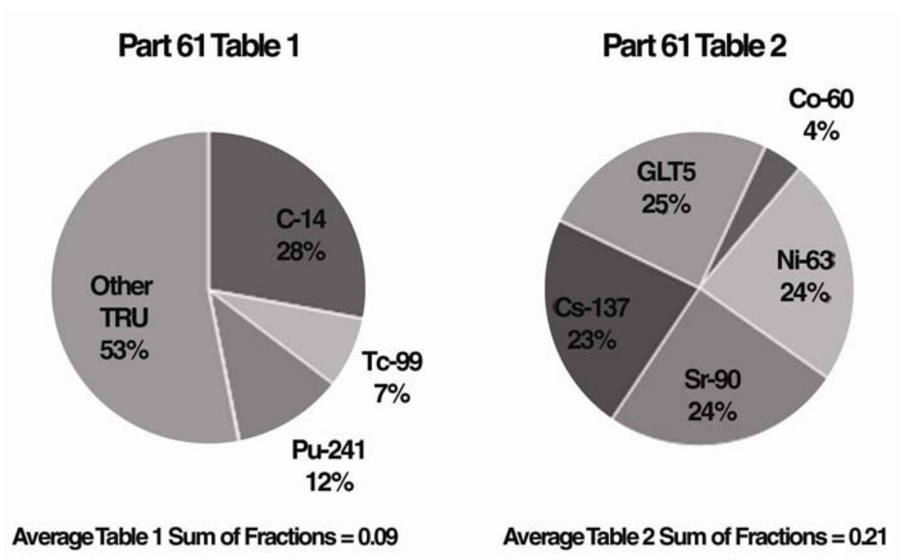

Figure 7-3
Nuclide Contributions to Classification (BWR Filter Streams)

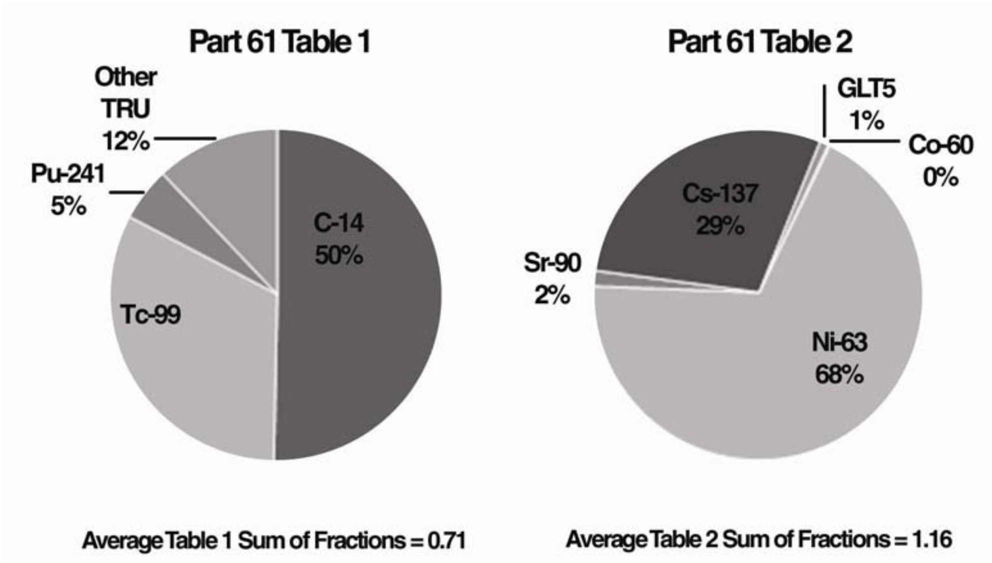

Figure 7-4
Nuclide Contributions to Classification (PWR Filter Streams)

For classification based on Part 61 Table 1, in BWR case, the overall sum-of- fractions is less than 1/10 of the Table 1 Class A limit. It is notable that Co-60 and short-lived gamma radionuclides (GLT5) make significant contributions to classification. In the PWR case, the average part 61 Table 1 sum of fractions is significant at 0.71. PWR filter classification, represented in Figure 7-4, by contrast is heavily dominated by Ni-63. In this case Ni-63 accounts for nearly 70 % of the classification. Cs-137 still remains significant at around 30 %.

For classification based on Part 61 Table 2, the average PWR sum of fraction exceeds the Class A limit by a factor of 1.16 while on average the BWR resins are less than the Class A limits. The major contributors to classification are Ni-63 at 68% in PWRs and Sr-90 along with Ni-63 both at 24 % in BWRs. Both PWR and BWR Table 2 fractions are show significant Cs-137 with the PWRs at 29% and the BWRs at 23%.

DAW - Classification

The results for BWR and PWR and dry active waste (DAW) are shown below in Figure 7-5 and Figure 7-6, respectively.

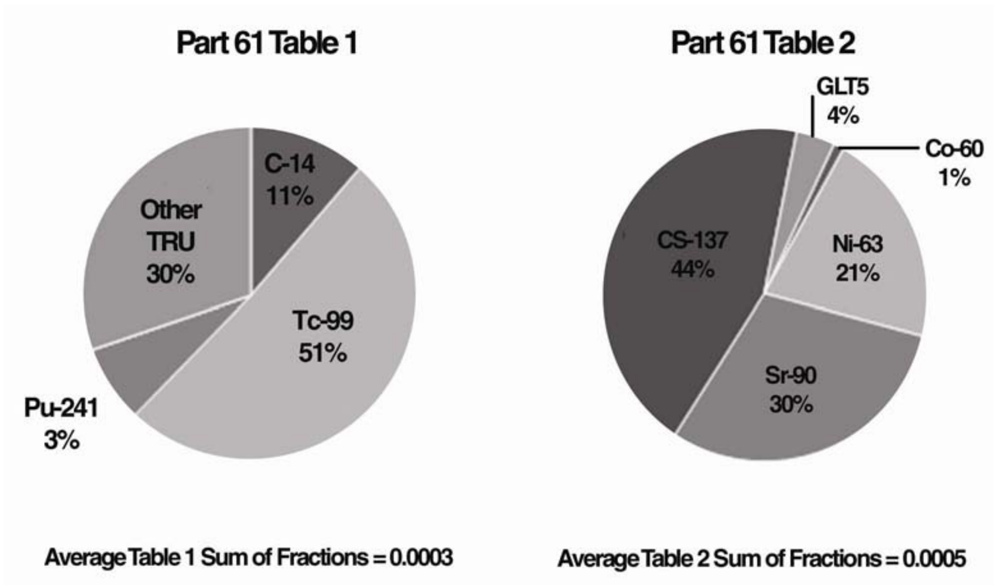

Figure 7-5
Nuclide Contributions to Classification (BWR DAW)

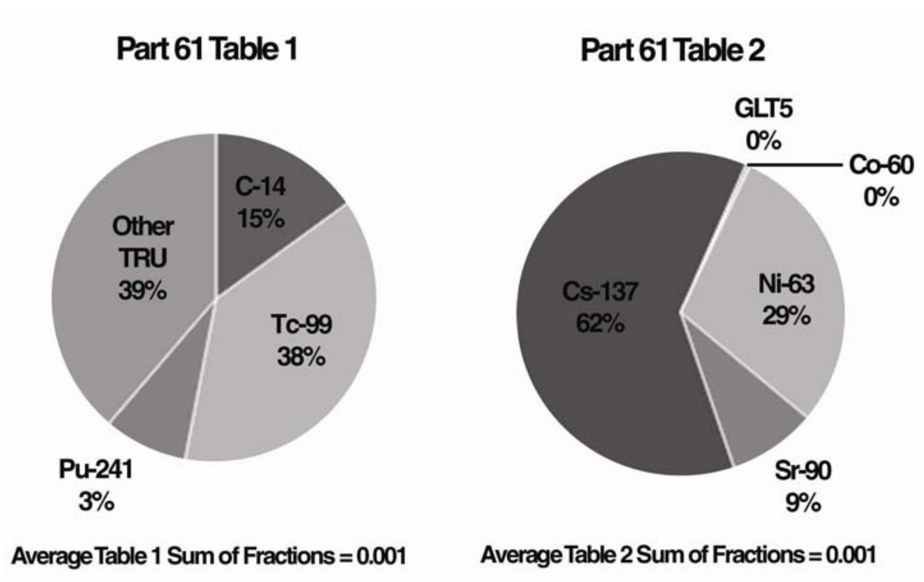

Figure 7-6
Nuclide Contributions to Classification (PWR DAW)

BWR DAW classification (Figure 7-5) is heavily dominated by Cs-137 and Sr-90 which together constitute about three quarters of the classification basis. Ni-63 accounts for additional 21%. PWR DAW classification, represented in Figure 7-6, shows a lesser contribution for Sr-90 and a larger contribution from Ni-63. In both cases Cs-137 is the strongest contributor to classification. A mechanistic argument for this behavior hasn't been developed. It's likely that surrogate sample bases are used for DAW packages. Additional attention may be required to the determination of Cs-137 in DAW. In any case, DAW accounts for a very small fraction of total activity. On average, the stream is well below Class A limits and on its own doesn't represent any disposal issues.

8 REFERENCES

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2. NUREG-0945, Final Environmental Impact Statement on 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste, September 1983
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4. NUREG/CR-4370, "Update of 10CFR61 Impacts Analysis Methodology, Volume 1: Methodology Report", USNRC, Washington DC, January 1986
5. Low-level Waste Licensing Branch Technical Position on Radioactive Waste Classification, USNRC, May 1983
6. United States Nuclear Regulatory Commission, "Technical Position on Waste Form", Low Level Waste Licensing Branch, Revision 1, January 1991
7. Branch Technical Position on Concentration Averaging and Encapsulation, USNRC, January 1995
8. Public Law 99-240 LOW-LEVEL RADIOACTIVE WASTE POLICY ACT, AMENDED, January 15, 19

A
INDIVIDUAL PLANT SUMMARIES

Volumes

The waste volumes for resins, filters and DAW for each plant were summed over the 4-year time span represented in the data received from each of the plants in the database, which in turn were summed to derive the total waste volume represented by these three waste streams. The totals were separated by reactor type (BWR or PWR) and sorted from lowest to highest. The following five tables present the BWR summaries by waste class and by waste steam, followed by five similar tables presenting the PWR summaries.

Table A-1 shows the BWR total waste volumes of the three waste streams on a plant-basis and on a reactor-unit basis generated over the past four years for the individual plants. The table contains two sorts; one for the total plant waste volume over the four year period and one on a per reactor unit over the four year period.

Table A-1
Four Year Waste Volume Totals for the Three Waste Streams for Individual BWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Number of Units	Reactor Type	Plant Four-Year Total Volume		Plant Designation	Four-Year Total Volume Per Reactor Unit
AS	1	BWR	9726(275.4)		AS	9726(275.4)
BP	1	BWR	21190(599.9)		BP	21190(599.9)
AU	1	BWR	33573(950.5)		BV	33543(949.7)
AR	1	BWR	39133(1108.0)		AU	33573(950.5)
AV	1	BWR	63472(1797.1)		AH	36622(1036.9)
BV	2	BWR	67086(1899.4)		AR	39133(1108.0)
AD	1	BWR	67995(1925.1)		BD	41436(1173.2)
AH	2	BWR	73243(2073.7)		BE	41705(1180.8)
AW	1	BWR	76020(2152.3)		AV	63472(1797.1)
BD	2	BWR	82872(2346.3)		AD	67995(1925.1)
BE	2	BWR	83411(2361.6)		BC	72129(2042.2)
AC	1	BWR	95293(2698.0)		AW	76020(2152.3)
AX	1	BWR	101457(2872.5)		BU	78149(2212.6)
BC	2	BWR	144259(4084.3)		BB	86015(2435.3)
BU	2	BWR	156297(4425.2)		AC	95293(2698.0)
BB	2	BWR	172030(4870.6)		AX	101457(2872.5)
BF	1	BWR	191246(5414.7)		BF	191246(5414.7)

Table A-2 gives the waste volumes for the BWR plants for Class A, B and C wastes over the four year time period. Each waste class has been sorted separately from lowest to highest.

Table A-2
Four Year Waste Volumes for Class A, B and C for Individual BWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Class A Volume		Plant Designation	Four-Year Class B Volume		Plant Designation	Four-Year Class C Volume
AS	9726(275.4)		AC	0(0.0)		AC	0(0.0)
BP	21190(599.9)		AD	0(0.0)		AH	0(0.0)
AU	32411(917.6)		AS	0(0.0)		AR	0(0.0)
AR	39060(1105.9)		BP	0(0.0)		AS	0(0.0)
AV	61283(1735.1)		AR	73(2.1)		AV	0(0.0)
BV	65490(1854.2)		BU	210(5.9)		AW	0(0.0)
AD	67690(1916.5)		BD	268(7.6)		AX	0(0.0)
AH	72504(2052.8)		BE	278(7.9)		BD	0(0.0)
AW	75620(2141.0)		AW	400(11.3)		BE	0(0.0)
BD	82604(2338.7)		AX	721(20.4)		BP	0(0.0)
BE	83133(2353.7)		AH	739(20.9)		BU	0(0.0)
AC	95293(2698.0)		BC	1115(31.6)		BV	0(0.0)
AX	100736(2852.1)		AU	1132(32.0)		AU	31(0.9)
BC	142896(4045.8)		BF	1408(39.9)		BF	114(3.2)
BU	156087(4419.2)		BV	1596(45.2)		BC	248(7.0)
BB	168126(4760.1)		AV	2189(62.0)		AD	305(8.6)
BF	189724(5371.6)		BB	3328(94.2)		BB	576(16.3)

The volume information in the above table was calculated on a reactor unit basis and re-sorted for all three classes as shown in Table A-3.

Table A-3
Four Year Waste Volumes for Class A, B and C for Individual BWR Plants on a per Reactor Unit Basis (Cubic Feet)

Plant Designation	Four-Year Class A Volume per Reactor Unit		Plant Designation	Four-Year Class B Volume per Reactor Unit		Plant Designation	Four-Year Class C Volume per Reactor Unit
AS	9726(275.4)		AC	0(0.0)		AC	0(0.0)
BP	21190(599.9)		AD	0(0.0)		AH	0(0.0)
AU	32411(917.6)		AS	0(0.0)		AR	0(0.0)
BV	32745(927.1)		BP	0(0.0)		AS	0(0.0)
AH	36252(1026.4)		AR	73(2.1)		AV	0(0.0)
AR	39060(1105.9)		BU	105(3.0)		AW	0(0.0)
BD	41302(1169.4)		BD	134(3.8)		AX	0(0.0)
BE	41566(1176.8)		BE	139(3.9)		BD	0(0.0)
AV	61283(1735.1)		AH	370(10.5)		BE	0(0.0)
AD	67690(1916.5)		AW	400(11.3)		BP	0(0.0)
BC	71448(2022.9)		BC	557(15.8)		BU	0(0.0)
AW	75620(2141.0)		BF	704(19.9)		BV	0(0.0)
BU	78044(2209.6)		AX	721(20.4)		AU	31(0.9)
BB	84063(2380.0)		BV	798(22.6)		BF	57(1.6)
BF	94862(2685.8)		AU	1132(32.0)		BC	124(3.5)
AC	95293(2698.0)		BB	1664(47.1)		BB	288(8.2)
AX	100736(2852.1)		AV	2189(62.0)		AD	305(8.6)

Table A-4 gives the four-year waste volumes for resins, filters and DAW for the individual BWR plants.

Table A-4
Four Year Waste Volumes for Resins, Filters and DAW Individual BWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Resin Volume		Plant Designation	Four-Year Filter Volume		Plant Designation	Four-Year DAW Volume
BP	1570(44.5)		AS	0(0.0)		AS	2986(84.5)
AU	4644(131.5)		BP	0(0.0)		BP	19620(555.5)
AD	5407(153.1)		AH	25(0.7)		AR	21001(594.6)
BV	5669(160.5)		AU	82(2.3)		AU	28848(816.8)
AV	5964(168.9)		AR	87(2.5)		AV	57370(1624.3)
AS	6740(190.8)		AV	138(3.9)		BV	59728(1691.1)
AH	7218(204.4)		AD	155(4.4)		AW	61740(1748.0)
BC	7609(215.4)		AC	169(4.8)		AD	62433(1767.6)
BE	7807(221.0)		BE	269(7.6)		AH	66000(1868.6)
AC	8599(243.5)		AW	330(9.3)		BD	69689(1973.1)
BU	9934(281.3)		BF	496(14.0)		BE	75336(2133.0)
AX	11016(311.9)		BB	502(14.2)		AC	86525(2449.7)
BD	12473(353.1)		AX	532(15.1)		AX	89909(2545.6)
BF	12487(353.5)		BD	710(20.1)		BC	135393(3833.3)
AW	13950(395.0)		BC	1257(35.6)		BU	142240(4027.2)
BB	16796(475.5)		BV	1689(47.8)		BB	154732(4380.9)
AR	18046(510.9)		BU	4123(116.7)		BF	178263(5047.1)

The volume information in the above table for the three waste streams was determined on a reactor unit basis and re-sorted for all three classes as shown in Table A-5.

Table A-5
Four Year Waste Volumes for Resins, Filters and DAW Individual BWR Plants on a per Reactor Unit Basis (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Resin Volume on a Reactor Unit Basis		Plant Designation	Four-Year Filter Volume on a Reactor Unit Basis		Plant Designation	Four-Year DAW Volume on a Reactor Unit Basis
BP	1570(44.5)		AS	0(0.0)		AS	2986(84.5)
BV	2835(80.3)		BP	0(0.0)		BP	19620(555.5)
AH	3609(102.2)		AH	13(0.4)		AR	21001(594.6)
BC	3804(107.7)		AU	82(2.3)		AU	28848(816.8)
BE	3903(110.5)		AR	87(2.5)		BV	29864(845.5)
AU	4644(131.5)		BE	134(3.8)		AH	33000(934.3)
BU	4967(140.6)		AV	138(3.9)		BD	34844(986.5)
AD	5407(153.1)		AD	155(4.4)		BE	37668(1066.5)
AV	5964(168.9)		AC	169(4.8)		AV	57370(1624.3)
BD	6237(176.6)		BF	248(7.0)		AW	61740(1748.0)
BF	6243(176.8)		BB	251(7.1)		AD	62433(1767.6)
AS	6740(190.8)		AW	330(9.3)		BC	67696(1916.6)
BB	8398(237.8)		BD	355(10.1)		BU	71120(2013.6)
AC	8599(243.5)		AX	532(15.1)		BB	77366(2190.4)
AX	11016(311.9)		BC	629(17.8)		AC	86525(2449.7)
AW	13950(395.0)		BV	844(23.9)		BF	89131(2523.5)
AR	18046(510.9)		BU	2061(58.4)		AX	89909(2545.6)

Table A-6 shows the PWR total waste volumes of the three waste streams on a plant-basis and on a reactor-unit basis generated over the past four years for the individual plants. Similar to the BWR data, the table contains two sorts; one for the total plant waste volume over the four year period and one on a per reactor unit over the four year period.

Table A-6
Four Year Waste Volume Totals for the Three Waste Streams for Individual PWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Number of Units	Reactor Type	Plant Four-Year Total Volume		Plant Designation	Reactor Unit Four-Year Total Volume
AO	2	PWR	918(26.0)		AO	459(13.0)
AI	1	PWR	1073(30.4)		AI	1073(30.4)
BL	1	PWR	1308(37.0)		BL	1308(37.0)
BQ	2	PWR	4478(126.8)		BQ	2239(63.4)
AK	1	PWR	4633(131.2)		AM	4583(129.8)
AY	1	PWR	8694(246.1)		AK	4633(131.2)
AM	2	PWR	9167(259.5)		AY	8694(246.1)
AB	1	PWR	18553(525.3)		AT	11066(313.3)
CB	1	PWR	21930(620.9)		AB	18553(525.3)
AT	2	PWR	22133(626.6)		AZ	21857(618.8)
AG	1	PWR	27499(778.6)		CB	21930(620.9)
AE	1	PWR	38339(1085.5)		CK	24584(696.0)
AZ	2	PWR	43713(1237.6)		CL	25008(708.0)
CK	2	PWR	49167(1392.0)		AG	27499(778.6)
CL	2	PWR	50016(1416.1)		BA	30605(866.5)
CG	1	PWR	58086(1644.6)		AL	32740(927.0)
BA	2	PWR	61210(1733.0)		AN	33097(937.1)
AL	2	PWR	65479(1853.9)		AE	38339(1085.5)
AN	2	PWR	66193(1874.1)		AP	40654(1151.0)
BS	1	PWR	75393(2134.6)		BJ	44288(1253.9)
AP	2	PWR	81308(2302.0)		AA	53156(1505.0)
BJ	2	PWR	88576(2507.8)		CG	58086(1644.6)
AA	2	PWR	106313(3010.0)		AQ	63784(1805.9)
BG	2	PWR	131007(3709.1)		BG	65503(1854.6)
AQ	3	PWR	191353(5417.7)		BS	75393(2134.6)

Table A-7 gives the waste volumes for the PWR plants for Class A, B and C wastes over the four year time period. Each waste class has been sorted separately from lowest to highest.

Table A-7
Four Year Waste Volume for Class A, B and C for Individual PWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Class A Volume		Plant Designation	Four-Year Class B Volume		Plant Designation	Four-Year Class C Volume
BL	174(4.9)		AI	0(0.0)		AE	0(0.0)
AO	553(15.7)		AP	207(5.9)		AI	0(0.0)
AI	1073(30.4)		AO	240(6.8)		AK	0(0.0)
BQ	3867(109.5)		CB	302(8.6)		AM	0(0.0)
AK	4114(116.5)		BS	382(10.8)		BA	0(0.0)
AY	8199(232.1)		AY	395(11.2)		BJ	0(0.0)
AM	8717(246.8)		AT	443(12.5)		BQ	0(0.0)
AB	17786(503.6)		AQ	446(12.6)		BG	8(0.2)
AT	21063(596.3)		AM	450(12.7)		AP	16(0.5)
CB	21267(602.1)		AE	471(13.3)		AG	18(0.5)
AG	26662(754.9)		BG	512(14.5)		BL	25(0.7)
AE	37868(1072.1)		AK	519(14.7)		CL	47(1.3)
AZ	41854(1185.0)		CL	554(15.7)		CK	66(1.9)
CK	48013(1359.4)		AB	597(16.9)		AQ	93(2.6)
CL	49415(1399.1)		BQ	611(17.3)		AN	94(2.7)
CG	56325(1594.7)		BJ	618(17.5)		AY	100(2.8)
BA	60385(1709.7)		AN	669(18.9)		CG	101(2.9)
AL	64199(1817.6)		AG	819(23.2)		BS	103(2.9)
AN	65430(1852.5)		BA	826(23.4)		AO	125(3.5)
BS	74908(2120.8)		AL	1068(30.2)		AB	170(4.8)
AP	81085(2295.7)		CK	1089(30.8)		AL	212(6.0)
BJ	87958(2490.3)		BL	1109(31.4)		AZ	334(9.5)
AA	102492(2901.8)		AZ	1526(43.2)		CB	361(10.2)
BG	130486(3694.4)		CG	1660(47.0)		AT	627(17.8)
AQ	190814(5402.4)		AA	2766(78.3)		AA	1054(29.8)

The volume information in the above table was calculated on a reactor unit basis and re-sorted for all three classes as shown in Table A-8.

Table A-8
Four Year Waste Volumes for Class A, B and C for Individual PWR Plants on a per Reactor Unit Basis (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Class A Volume per Reactor Unit		Plant Designation	Four-Year Class B Volume per Reactor Unit		Plant Designation	Four-Year Class C Volume per Reactor Unit
BL	174(4.9)		AI	0(0.0)		AE	0(0.0)
AO	276(7.8)		AP	103(2.9)		AI	0(0.0)
AI	1073(30.4)		AO	120(3.4)		AK	0(0.0)
BQ	1934(54.8)		AQ	149(4.2)		AM	0(0.0)
AK	4114(116.5)		AT	222(6.3)		BA	0(0.0)
AM	4358(123.4)		AM	225(6.4)		BJ	0(0.0)
AY	8199(232.1)		BG	256(7.2)		BQ	0(0.0)
AT	10532(298.2)		CL	277(7.8)		BG	4(0.1)
AB	17786(503.6)		CB	302(8.6)		AP	8(0.2)
AZ	20927(592.5)		BQ	306(8.7)		AG	18(0.5)
CB	21267(602.1)		BJ	309(8.7)		CL	23(0.7)
CK	24006(679.7)		AN	334(9.5)		BL	25(0.7)
CL	24707(699.5)		BS	382(10.8)		AQ	31(0.9)
AG	26662(754.9)		AY	395(11.2)		CK	33(0.9)
BA	30192(854.8)		BA	413(11.7)		AN	47(1.3)
AL	32099(908.8)		AE	471(13.3)		AO	63(1.8)
AN	32715(926.2)		AK	519(14.7)		AY	100(2.8)
AE	37868(1072.1)		AL	534(15.1)		CG	101(2.9)
AP	40542(1147.8)		CK	544(15.4)		BS	103(2.9)
BJ	43979(1245.2)		AB	597(16.9)		AL	106(3.0)
AA	51246(1450.9)		AZ	763(21.6)		AZ	167(4.7)
CG	56325(1594.7)		AG	819(23.2)		AB	170(4.8)
AQ	63605(1800.8)		BL	1109(31.4)		AT	313(8.9)
BG	65243(1847.2)		AA	1383(39.2)		CB	361(10.2)
BS	74908(2120.8)		CG	1660(47.0)		AA	527(14.9)

Table A-9 gives the four-year waste volumes for resins, filters and DAW for the individual PWR plants.

Table A-9
Four Year Waste Volume for Resins, Filters and DAW Individual PWR Plants (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Resin Volume	Plant Designation	Four-Year Filter Volume	Plant Designation	Four-Year DAW Volume
AK	460(13.0)	AB	0(0.0)	BL	0(0.0)
BS	583(16.5)	AE	o(0.0)	AO	100(2.8)
AN	691(19.6)	AI	0(0.0)	AI	192(5.4)
AO	693(19.6)	AM	0(0.0)	BQ	3411(96.6)
AI	881(24.9)	AY	0(0.0)	AK	4096(116.0)
AM	1061(30.0)	BJ	0(0.0)	AY	7296(206.6)
BQ	1067(30.2)	BQ	0(0.0)	AM	8106(229.5)
AG	1202(34.0)	AT	27(0.8)	AB	16671(472.0)
BL	1267(35.9)	BL	41(1.2)	CB	17493(495.3)
AY	1398(39.6)	AP	45(1.3)	AT	20491(580.2)
AT	1615(45.7)	BG	69(2.0)	AG	26196(741.7)
AB	1882(53.3)	AK	77(2.2)	AE	31788(900.0)
AP	1994(56.5)	CK	86(2.4)	AZ	31801(900.4)
CG	2095(59.3)	BA	95(2.7)	CK	45025(1274.8)
BJ	3595(101.8)	CL	96(2.7)	CL	45757(1295.5)
CK	4056(114.8)	AG	101(2.9)	BA	49964(1414.6)
CL	4163(117.9)	AO	125(3.5)	AL	54608(1546.1)
CB	4266(120.8)	CB	171(4.8)	CG	55800(1579.8)
AQ	4745(134.3)	CG	191(5.4)	AN	65256(1847.6)
AL	5682(160.9)	AN	246(7.0)	BS	74557(2110.9)
AE	6551(185.5)	BS	253(7.2)	AP	79268(2244.3)
BG	8092(229.1)	AQ	314(8.9)	BJ	84981(2406.0)
AA	9902(280.4)	AZ	386(10.9)	AA	94997(2689.6)
BA	11152(315.7)	AA	1414(40.0)	BG	122847(3478.1)
AZ	11526(326.3)	AL	5189(146.9)	AQ	186294(5274.5)

The volume information in the above table for the three waste streams was determined on a reactor unit basis and re-sorted for all three classes as shown in Table A-10.

Table A-10
Four Year Waste Volumes for Resins, Filters and DAW Individual PWR Plants on a per Reactor Unit Basis (Volumes in ft^3 corresponding volume in m^3 shown in parentheses)

Plant Designation	Four-Year Resin Volume on a Reactor Unit Basis	Plant Designation	Four-Year Filter Volume on a Reactor Unit Basis	Plant Designation	Four-Year DAW Volume on a Reactor Unit Basis
AN	346(9.8)	AB	0(0.0)	BL	0(0.0)
AO	346(9.8)	AE	0(0.0)	AO	50(1.4)
AK	460(13.0)	AI	0(0.0)	AI	192(5.4)
AM	530(15.0)	AM	0(0.0)	BQ	1706(48.3)
BQ	534(15.1)	AY	0(0.0)	AM	4053(114.8)
BS	583(16.5)	BJ	0(0.0)	AK	4096(116.0)
AT	807(22.8)	BQ	0(0.0)	AY	7296(206.6)
AI	881(24.9)	AT	14(0.4)	AT	10246(290.1)
AP	997(28.2)	AP	23(0.7)	AZ	15901(450.2)
AG	1202(34.0)	BG	34(1.0)	AB	16671(472.0)
BL	1267(35.9)	BL	41(1.2)	CB	17493(495.3)
AY	1398(39.6)	CK	43(1.2)	CK	22512(637.4)
AQ	1582(44.8)	BA	47(1.3)	CL	22879(647.8)
BJ	1797(50.9)	CL	48(1.4)	BA	24982(707.3)
AB	1882(53.3)	AO	63(1.8)	AG	26196(741.7)
CK	2028(57.4)	AK	77(2.2)	AL	27304(773.0)
CL	2082(58.9)	AG	101(2.9)	AE	31788(900.0)
CG	2095(59.3)	AQ	105(3.0)	AN	32628(923.8)
AL	2841(80.4)	AN	123(3.5)	AP	39634(1122.1)
BG	4046(114.6)	CB	171(4.8)	BJ	42491(1203.0)
CB	4266(120.8)	CG	191(5.4)	AA	47498(1344.8)
AA	4951(140.2)	AZ	193(5.5)	CG	55800(1579.8)
BA	5576(157.9)	BS	253(7.2)	BG	61423(1739.0)
AZ	5763(163.2)	AA	707(20.0)	AQ	62098(1758.2)
AE	6551(185.5)	AL	2595(73.5)	BS	74557(2110.9)

Radiological Characteristics

The curies in resins, filters and DAW for each plant were summed over the 4-year time span represented in the data received from each of the plants in the database, which in turn were summed to derive the total curies volume represented by these three waste streams. The totals were separated by reactor type (BWR or PWR) and sorted from lowest to highest. The following five tables present the BWR curie summaries by waste class and waste stream, followed by five similar tables presenting the PWR summaries.

Table A-11 shows the BWR total curies in the three waste streams on a plant-basis and on a reactor-unit basis generated over the past four years for the individual plants. The table contains two sorts; one for the total plant waste volume over the four year period and one on a per reactor unit over the four year period.

Table A-11
Four Year Curie Totals for the Three Waste Streams for Individual BWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Number of Units	Reactor Type	Total Curies All Waste		Plant Designation	Total Curies All Waste Per Reactor Unit
BP	1	BWR	112(4.1)		BP	112(4.1)
AS	1	BWR	296(11.0)		AS	296(11.0)
AD	1	BWR	486(18.0)		BE	457(16.9)
BE	2	BWR	914(33.8)		AD	486(18.0)
AV	1	BWR	1083(40.1)		BD	639(23.6)
BD	2	BWR	1278(47.3)		BC	709(26.2)
BC	2	BWR	1418(52.5)		BV	869(32.2)
AU	1	BWR	1523(56.4)		AV	1083(40.1)
BV	2	BWR	1738(64.3)		AH	1176(43.5)
AH	2	BWR	2352(87.0)		AU	1523(56.4)
AC	1	BWR	2541(94.0)		AC	2541(94.0)
AR	1	BWR	2689(99.5)		AR	2689(99.5)
AX	1	BWR	2957(109.4)		AX	2957(109.4)
BB	2	BWR	6325(234.0)		BB	3162(117.0)
AW	1	BWR	6488(240.1)		BU	5295(195.9)
BU	2	BWR	10590(391.8)		BF	6049(223.8)
BF	2	BWR	12097(447.6)		AW	6488(240.1)

Table A-12 gives the waste volumes for the BWR plants for Class A, B and C wastes over the four year time period. Each waste class has been sorted separately from lowest to highest.

Table A-12
Four Year Curies in Class A, B and C for Individual BWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Class A Total Curies		Plant Designation	Class B Total Curies		Plant Designation	Class C Total Curies
BP	110(4.1)		AC	0(0.0)		AC	0(0.0)
AV	138(5.1)		AD	0(0.0)		AH	0(0.0)
BV	144(5.3)		AS	0(0.0)		AR	0(0.0)
AS	294(10.9)		BP	0(0.0)		AS	0(0.0)
AD	359(13.3)		AR	72(2.7)		AV	0(0.0)
BC	491(18.2)		BE	409(15.1)		AW	0(0.0)
BE	502(18.6)		AU	422(15.6)		AX	0(0.0)
AH	581(21.5)		BC	568(21.0)		BD	0(0.0)
BD	615(22.8)		BD	659(24.4)		BE	0(0.0)
AU	796(29.5)		AV	943(34.9)		BP	0(0.0)
AX	1011(37.4)		BV	1591(58.9)		BU	0(0.0)
AC	2539(93.9)		AH	1767(65.4)		BV	0(0.0)
AR	2615(96.8)		AX	1944(71.9)		AD	125(4.6)
BB	2694(99.7)		BB	3324(123.0)		AU	302(11.2)
AW	2732(101.1)		AW	3754(138.9)		BB	303(11.2)
BU	5516(204.1)		BU	5070(187.6)		BF	352(13.0)
BF	5855(216.6)		BF	5887(217.8)		BC	355(13.1)

The volume information in the above table was calculated on a reactor unit basis and re-sorted for all three classes as shown in Table A-13.

Table A-13
Four Year Curies in Class A, B and C for Individual BWR Plants on a per Reactor Unit Basis (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Class A Total Curies per Reactor Unit		Plant Designation	Class B Total Curies per Reactor Unit		Plant Designation	Class C Total Curies per Reactor Unit
BV	72(2.7)		AC	0(0.0)		AC	0(0.0)
BP	110(4.1)		AD	0(0.0)		AH	0(0.0)
AV	138(5.1)		AS	0(0.0)		AR	0(0.0)
BC	246(9.1)		BP	0(0.0)		AS	0(0.0)
BE	251(9.3)		AR	72(2.7)		AV	0(0.0)
AH	290(10.7)		BE	204(7.5)		AW	0(0.0)
AS	294(10.9)		BC	284(10.5)		AX	0(0.0)
BD	308(11.4)		BD	330(12.2)		BD	0(0.0)
AD	359(13.3)		AU	422(15.6)		BE	0(0.0)
AU	796(29.5)		BV	795(29.4)		BP	0(0.0)
AX	1011(37.4)		AH	883(32.7)		BU	0(0.0)
BB	1347(49.8)		AV	943(34.9)		BV	0(0.0)
AC	2539(93.9)		BB	1662(61.5)		AD	125(4.6)
AR	2615(96.8)		AX	1944(71.9)		BB	152(5.6)
AW	2732(101.1)		BU	2535(93.8)		BF	176(6.5)
BU	2758(102.0)		BF	2944(108.9)		BC	177(6.5)
BF	2927(108.3)		AW	3754(138.9)		AU	302(11.2)

Table A-14 gives the four-year waste volumes for resins, filters and DAW for the individual BWR plants.

Table A-14
Four-Year Curies in Resins, Filters and DAW Individual BWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Resins Total Curies		Plant Designation	Filters Total Curies		Plant Designation	DAW Total Curies
BP	107(4.0)		AS	0(0.0)		AS	0(0.0)
AS	293(10.8)		BP	0(0.0)		AD	2(0.1)
AD	454(16.8)		AV	2(0.1)		BP	3(0.1)
BU	484(17.9)		BE	6(0.2)		AH	4(0.1)
BE	897(33.2)		BD	12(0.4)		AU	4(0.1)
BC	1036(38.3)		AH	18(0.7)		AV	5(0.2)
AV	1074(39.7)		AD	28(1.0)		BV	7(0.3)
AU	1206(44.6)		BV	58(2.1)		BE	7(0.3)
BD	1248(46.2)		AR	82(3.0)		AC	11(0.4)
BV	1670(61.8)		AX	87(3.2)		BD	15(0.6)
AC	1714(63.4)		AW	262(9.7)		AW	15(0.6)
AH	2326(86.1)		AU	311(11.5)		BB	16(0.6)
AR	2548(94.3)		BB	345(12.8)		BC	16(0.6)
AX	2794(103.4)		BC	362(13.4)		AR	57(2.1)
BB	5960(220.5)		BF	602(22.3)		BF	62(2.3)
AW	6209(229.7)		AC	814(30.1)		BU	73(2.7)
BF	11430(422.9)		BU	10030(371.1)		AX	74(2.7)

The volume information in the above table for the three waste streams was determined on a reactor unit basis and re-sorted for all three classes as shown in Table A-15.

Table A-15
Four-Year Curies in Resins, Filters and DAW Individual BWR Plants on a per Reactor Unit Basis (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Resins Total Curies per Reactor Unit		Plant Designation	Filters Total Curies per Reactor Unit		Plant Designation	DAW Total Curies per Reactor Unit
BP	107(4.0)		AS	0(0.0)		AS	0(0.0)
BU	242(9.0)		BP	0(0.0)		AH	2(0.1)
AS	293(10.8)		AV	2(0.1)		AD	2(0.1)
BE	449(16.6)		BE	3(0.1)		BP	3(0.1)
AD	454(16.8)		BD	6(0.2)		BV	3(0.1)
BC	518(19.2)		AH	9(0.3)		BE	4(0.1)
BD	624(23.1)		AD	28(1.0)		AU	4(0.1)
BV	835(30.9)		BV	29(1.1)		AV	5(0.2)
AV	1074(39.7)		AR	82(3.0)		BD	7(0.3)
AH	1163(43.0)		AX	87(3.2)		BB	8(0.3)
AU	1206(44.6)		BB	173(6.4)		BC	8(0.3)
AC	1714(63.4)		BC	181(6.7)		AC	11(0.4)
AR	2548(94.3)		AW	262(9.7)		AW	15(0.6)
AX	2794(103.4)		BF	301(11.1)		BF	31(1.1)
BB	2980(110.3)		AU	311(11.5)		BU	36(1.3)
BF	5715(211.5)		AC	814(30.1)		AR	57(2.1)
AW	6209(229.7)		BU	5015(185.6)		AX	74(2.7)

Table A-16 shows the PWR total curies in all three waste streams on a plant-basis and on a reactor-unit basis generated over the past four years for the individual plants. Similar to the BWR data, the table contains two sorts; one for the total plant curies over the four year period and one on a per reactor unit over the four year period.

Table A-16
Four-Year Curies in All Three Waste Streams for Individual PWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Number of Units	Reactor Type	Total Curies All Waste		Plant Designation	Total Curies All Waste Per Reactor Unit
AI	1	PWR	9(0.3)		AI	9(0.3)
AE	1	PWR	168(6.2)		AP	106(3.9)
AP	2	PWR	213(7.9)		AE	168(6.2)
AK	1	PWR	294(10.9)		BJ	174(6.4)
BJ	2	PWR	348(12.9)		AQ	198(7.3)
BQ	2	PWR	411(15.2)		BQ	206(7.6)
BS	1	PWR	468(17.3)		AM	265(9.8)
AM	2	PWR	530(19.6)		AO	288(10.7)
AO	2	PWR	576(21.3)		AK	294(10.9)
AQ	3	PWR	593(21.9)		BG	315(11.7)
AG	1	PWR	627(23.2)		BS	468(17.3)
BG	2	PWR	629(23.3)		BA	484(17.9)
BL	1	PWR	674(24.9)		AL	501(18.5)
BA	2	PWR	968(35.8)		AG	627(23.2)
AL	2	PWR	1003(37.1)		CK	637(23.6)
CB	1	PWR	1075(39.8)		CL	656(24.3)
AB	1	PWR	1107(41.0)		BL	674(24.9)
CK	2	PWR	1273(47.1)		AZ	887(32.8)
CL	2	PWR	1312(48.5)		AN	891(33.0)
CG	1	PWR	1626(60.2)		CB	1075(39.8)
AZ	2	PWR	1774(65.6)		AB	1107(41.0)
AN	2	PWR	1782(65.9)		AT	1269(47.0)
AY	1	PWR	2227(82.4)		AA	1595(59.0)
AT	2	PWR	2539(93.9)		CG	1626(60.2)
AA	2	PWR	3190(118.0)		AY	2227(82.4)

Table A-17 gives the curies in PWR plants in Class A, B and C wastes over the four year time period. Each waste class has been sorted separately from lowest to highest.

Table A-17
Four-Year Curies in Class A, B and C for Individual PWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Class A Total Curies		Plant Designation	Class B Total Curies		Plant Designation	Class C Total Curies
AK	0		AI	0(0.0)		AE	0(0.0)
AM	3		AT	62(2.3)		AI	0(0.0)
AI	7		AE	124(4.6)		AK	0(0.0)
BQ	9		AO	127(4.7)		AM	0(0.0)
BS	10		AP	158(5.8)		BA	0(0.0)
BL	12		BS	198(7.3)		BJ	0(0.0)
AY	13		CB	246(9.1)		BQ	0(0.0)
AO	13		AK	292(10.8)		AG	3(0.1)
CG	22		BJ	305(11.3)		BG	17(0.6)
AB	22		AQ	347(12.8)		AP	24(0.9)
CB	24		AB	396(14.7)		BL	48(1.8)
CL	26		BQ	398(14.7)		CK	107(4.0)
AP	27		AL	497(18.4)		AQ	211(7.8)
AQ	29		BG	501(18.5)		BS	258(9.5)
AT	32		AM	523(19.4)		AL	392(14.5)
AN	34		AG	547(20.2)		AO	431(15.9)
BJ	40		BL	612(22.6)		AZ	445(16.5)
AE	42		CL	690(25.5)		AN	483(17.9)
AG	76		BA	693(25.6)		CG	505(18.7)
CK	98		AY	992(36.7)		CL	592(21.9)
BG	108		CK	1065(39.4)		AB	688(25.5)
AL	110		CG	1097(40.6)		CB	802(29.7)
AZ	112		AZ	1213(44.9)		AY	1220(45.1)
AA	181		AN	1261(46.7)		AA	1265(46.8)
BA	271		AA	1740(64.4)		AT	2441(90.3)

The curie information in the above table was calculated on a reactor unit basis and re-sorted for all three classes as shown in Table A-18.

Table A-18
Four-Year Curies in Class A, B and C for Individual PWR Plants on a per Reactor Unit Basis (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Class A Total Curies per Reactor Unit		Plant Designation	Class B Total Curies per Reactor Unit		Plant Designation	Class C Total Curies per Reactor Unit
AK	0(0.0)		AI	0(0.0)		AE	0(0.0)
AM	2(0.1)		AT	31(1.1)		AI	0(0.0)
BQ	4(0.1)		AO	64(2.4)		AK	0(0.0)
AO	7(0.3)		AP	79(2.9)		AM	0(0.0)
AI	7(0.3)		AQ	116(4.3)		BA	0(0.0)
BS	10(0.4)		AE	124(4.6)		BJ	0(0.0)
AQ	10(0.4)		BJ	152(5.6)		BQ	0(0.0)
BL	12(0.4)		BS	198(7.3)		AG	3(0.1)
AY	13(0.5)		BQ	199(7.4)		BG	8(0.3)
CL	13(0.5)		CB	246(9.1)		AP	12(0.4)
AP	14(0.5)		AL	249(9.2)		BL	48(1.8)
AT	16(0.6)		BG	250(9.3)		CK	54(2.0)
AN	17(0.6)		AM	261(9.7)		AQ	70(2.6)
BJ	20(0.7)		AK	292(10.8)		AL	196(7.3)
CG	22(0.8)		CL	345(12.8)		AO	216(8.0)
AB	22(0.8)		BA	346(12.8)		AZ	223(8.3)
CB	24(0.9)		AB	396(14.7)		AN	241(8.9)
AE	42(1.6)		CK	532(19.7)		BS	258(9.5)
CK	49(1.8)		AG	547(20.2)		CL	296(11.0)
BG	54(2.0)		AZ	607(22.5)		CG	505(18.7)
AL	55(2.0)		BL	612(22.6)		AA	632(23.4)
AZ	56(2.1)		AN	631(23.3)		AB	688(25.5)
AG	76(2.8)		AA	870(32.2)		CB	802(29.7)
AA	90(3.3)		AY	992(36.7)		AY	1220(45.1)
BA	135(5.0)		CG	1097(40.6)		AT	1221(45.2)

Table A-19 gives the four-year waste volumes for resins, filters and DAW for the individual PWR plants.

Table A-19
Four-Year Curies in Resins, Filters and DAW Individual PWR Plants (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Resins Total Curies		Plant Designation	Filters Total Curies		Plant Designation	DAW Total Curies
AI	7(0.3)		AB	0(0.0)		BL	0(0.0)
AO	133(4.9)		AE	0(0.0)		AI	0(0.0)
AP	153(5.7)		AI	0(0.0)		BQ	0(0.0)
AE	163(6.0)		AM	0(0.0)		AB	0(0.0)
AK	253(9.4)		AY	0(0.0)		AK	0(0.0)
AQ	330(12.2)		BJ	0(0.0)		AM	1(0.0)
BJ	339(12.5)		BQ	0(0.0)		AY	1(0.0)
BQ	407(15.1)		BS	2(0.1)		AE	2(0.1)
BS	459(17.0)		BG	27(1.0)		AG	3(0.1)
AM	525(19.4)		BA	32(1.2)		CG	4(0.1)
AG	560(20.7)		AP	32(1.2)		AZ	5(0.2)
BG	594(22.0)		AK	39(1.4)		BG	5(0.2)
BL	621(23.0)		BL	50(1.9)		BJ	5(0.2)
AL	904(33.4)		CL	59(2.2)		BS	6(0.2)
BA	924(34.2)		AG	62(2.3)		CK	6(0.2)
AN	948(35.1)		CB	67(2.5)		AO	7(0.3)
CB	994(36.8)		AT	79(2.9)		AA	7(0.3)
AB	1105(40.9)		AL	82(3.0)		BA	8(0.3)
CG	1112(41.1)		CK	108(4.0)		CL	8(0.3)
CK	1155(42.7)		AZ	148(5.5)		CB	11(0.4)
CL	1241(45.9)		AQ	212(7.8)		AL	12(0.4)
AZ	1618(59.9)		AO	431(15.9)		AP	24(0.9)
AY	2223(82.3)		CG	508(18.8)		AT	25(0.9)
AT	2431(89.9)		AA	586(21.7)		AN	32(1.2)
AA	2592(95.9)		AN	798(29.5)		AQ	46(1.7)

The curie information in the above table for the three waste streams was calculated on a reactor unit basis and re-sorted for all three waste streams as shown in Table A-20.

Table A-20
Four-Year Waste Curies in Resins, Filters and DAW Individual PWR Plants on a per Reactor Unit Basis (Activities in Curies corresponding value in TBq shown in parentheses)

Plant Designation	Resins Total Curies per Reactor Unit		Plant Designation	Filters Total Curies per Reactor Unit		Plant Designation	DAW Total Curies per Reactor Unit
AI	7(0.3)		AB	0(0.0)		BL	0(0.0)
AO	67(2.5)		AE	0(0.0)		AI	0(0.0)
AP	77(2.8)		AI	0(0.0)		BQ	0(0.0)
AQ	110(4.1)		AM	0(0.0)		AB	0(0.0)
AE	163(6.0)		AY	0(0.0)		AK	0(0.0)
BJ	170(6.3)		BJ	0(0.0)		AM	0(0.0)
BQ	204(7.5)		BQ	0(0.0)		AY	1(0.03)
AK	253(9.4)		BS	2(0.1)		AE	2(0.1)
AM	262(9.7)		BG	13(0.5)		AZ	2(0.1)
BG	297(11.0)		BA	16(0.6)		BG	2(0.1)
AL	452(16.7)		AP	16(0.6)		BJ	3(0.1)
BS	459(17.0)		CL	29(1.1)		AG	3(0.1)
BA	462(17.1)		AK	39(1.4)		CK	3(0.1)
AN	474(17.5)		AT	40(1.5)		AO	3(0.1)
AG	560(20.7)		AL	41(1.5)		AA	4(0.1)
CK	578(21.4)		BL	50(1.9)		BA	4(0.1)
CL	620(22.9)		CK	54(2.0)		CG	4(0.1)
BL	621(23.0)		AG	62(2.3)		CL	4(0.1)
AZ	809(29.9)		CB	67(2.5)		BS	6(0.2)
CB	994(36.8)		AQ	71(2.6)		AL	6(0.2)
AB	1105(40.9)		AZ	74(2.7)		CB	11(0.4)
CG	1112(41.1)		AO	216(8.0)		AP	12(0.4)
AT	1215(45.0)		AA	293(10.8)		AT	12(0.4)
AA	1296(48.0)		AN	399(14.8)		AQ	15(0.6)
AY	2223(82.3)		CG	508(18.8)		AN	16(0.6)

Waste Characterization Data

The data received in the information request made to the individual plants included the curies in each package for individual radionuclides. Database search routines were used to extract the curie value for each package for each of the 10CFR61 radionuclides along with the package waste volume. These were summed to derive an average concentration for each of the radionuclides for an entire waste stream over the four year time span. Table A-21 shows the average concentrations over four years of the 10CFR61 radionuclides in BWR resins in the individual plants. Because Cs-137 controls the classification of Class A resin waste, the radionuclide concentrations were sorted from lowest to highest based on the Cs-137 concentration.

Table A-21
Average 10CFR61 Radionuclide Concentrations in Resin Waste In BWR Plants (Activities in Curies/m³ corresponding value in GBq/m³ shown in parentheses)

Plant Designation	# of Units	React or Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BU	2	BWR	4.1E-01 (1.5E+01)	4.5E-03 (1.6E-01)	1.9E-04 (6.8E-03)	3.1E-04 (1.1E-02)	2.9E-02 (1.1E+00)	6.8E-08 (2.5E-06)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AC	1	BWR	1.2E+00 (4.4E+01)	4.2E-02 (1.5E+00)	8.7E-05 (3.2E-03)	2.2E-03 (8.1E-02)	2.5E-02 (9.2E-01)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AR	1	BWR	2.2E+00 (8.0E+01)	6.6E-02 (2.4E+00)	1.5E-04 (5.6E-03)	1.3E-02 (4.9E-01)	8.1E-03 (3.0E-01)	5.2E-06 (1.9E-04)	7.2E-05 (2.7E-03)	1.4E-06 (5.2E-05)
AW	1	BWR	9.3E-01 (3.5E+01)	4.8E-02 (1.8E+00)	8.2E-03 (3.0E-01)	2.5E-02 (9.4E-01)	2.2E-03 (8.0E-02)	5.8E-04 (2.1E-02)	8.1E-04 (3.0E-02)	1.5E-05 (5.6E-04)
AS	1	BWR	2.4E-01 (8.8E+00)	2.0E-02 (7.4E-01)	1.5E-03 (5.7E-02)	3.7E-02 (1.4E+00)	5.7E-03 (2.1E-01)	7.4E-06 (2.7E-04)	1.5E-04 (5.4E-03)	5.8E-06 (2.2E-04)
AD	1	BWR	3.1E-01 (1.2E+01)	6.6E-03 (2.4E-01)	1.3E-03 (4.9E-02)	7.4E-02 (2.7E+00)	4.1E-02 (1.5E+00)	1.4E-03 (5.1E-02)	1.1E-02 (4.0E-01)	2.1E-04 (7.8E-03)
BE	2	BWR	1.8E+00 (6.5E+01)	8.7E-02 (3.2E+00)	1.6E-03 (6.0E-02)	9.6E-02 (3.5E+00)	7.8E-03 (2.9E-01)	5.2E-05 (1.9E-03)	5.5E-05 (2.0E-03)	7.4E-06 (2.7E-04)
AX	1	BWR	1.6E+00 (5.9E+01)	3.2E-02 (1.2E+00)	4.5E-03 (1.7E-01)	1.1E-01 (4.0E+00)	1.5E-03 (5.6E-02)	1.7E-04 (6.1E-03)	1.9E-03 (6.9E-02)	5.3E-05 (2.0E-03)
BD	2	BWR	2.1E+00 (7.7E+01)	1.3E-01 (4.8E+00)	4.2E-04 (1.6E-02)	1.7E-01 (6.4E+00)	1.8E-02 (6.5E-01)	6.6E-05 (2.4E-03)	2.4E-03 (8.9E-02)	1.0E-07 (3.8E-06)
BV	2	BWR	5.9E+00 (2.2E+02)	3.7E-01 (1.4E+01)	7.1E-03 (2.6E-01)	3.0E-01 (1.1E+01)	1.4E-02 (5.3E-01)	4.8E-05 (1.8E-03)	7.1E-04 (2.6E-02)	2.3E-05 (8.6E-04)
AH	2	BWR	3.5E+00 (1.3E+02)	7.6E-02 (2.8E+00)	1.5E-03 (5.5E-02)	3.8E-01 (1.4E+01)	1.7E-03 (6.1E-02)	1.3E-04 (4.8E-03)	7.7E-04 (2.9E-02)	3.6E-05 (1.3E-03)

Table A-21
Average 10CFR61 Radionuclide Concentrations in Resin Waste In BWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses) (continued)

Plant Designation	# of Units	React or Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BC	2	BWR	2.7E+00 (9.8E+01)	9.9E-02 (3.7E+00)	8.3E-03 (3.1E-01)	4.0E-01 (1.5E+01)	7.2E-02 (2.6E+00)	2.1E-04 (7.7E-03)	2.7E-03 (9.9E-02)	1.9E-05 (7.0E-04)
BP	1	BWR	7.6E-01 (2.8E+01)	2.5E-02 (9.4E-01)	1.3E-03 (4.9E-02)	4.3E-01 (1.6E+01)	2.2E-03 (8.3E-02)	1.7E-04 (6.4E-03)	7.6E-04 (2.8E-02)	3.0E-05 (1.1E-03)
BF	1	BWR	9.2E+00 (3.4E+02)	1.4E-01 (5.3E+00)	7.5E-03 (2.8E-01)	4.7E-01 (1.7E+01)	2.8E-03 (1.0E-01)	2.6E-04 (9.8E-03)	3.6E-03 (1.3E-01)	1.3E-04 (4.7E-03)
BB	2	BWR	2.9E+00 (1.1E+02)	1.0E-01 (3.8E+00)	7.4E-03 (2.8E-01)	5.0E-01 (1.8E+01)	2.3E-02 (8.5E-01)	5.0E-04 (1.8E-02)	3.6E-03 (1.3E-01)	2.5E-05 (9.3E-04)
AV	1	BWR	2.0E+00 (7.4E+01)	4.1E-01 (1.5E+01)	1.2E-02 (4.6E-01)	5.4E-01 (2.0E+01)	5.9E-03 (2.2E-01)	2.0E-04 (7.3E-03)	1.1E-03 (3.9E-02)	1.4E-05 (5.1E-04)
AU	1	BWR	9.0E-01 (3.3E+01)	9.8E-02 (3.6E+00)	4.2E-04 (1.6E-02)	1.9E+00 (7.2E+01)	2.0E-02 (7.4E-01)	2.8E-04 (1.0E-02)	5.1E-04 (1.9E-02)	3.6E-06 (1.3E-04)

The companion table for PWRs is shown in Table A-22. In PWR resins the Class A waste classification will generally be controlled by Ni-63 unless the plant operates for some time with failed fuel. In the case of failed fuel, Cs-137 will likely control the waste classification. In Table A-22 the individual plants have been sorted by the Cs-137 concentrations.

Table A-22
Average 10CFR61 Radionuclide Concentrations in Resin Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AI	1	PWR	2.8E-02 (1.0E+00)	1.2E-01 (4.4E+00)	2.1E-04 (7.7E-03)	1.3E-02 (4.9E-01)	5.8E-04 (2.1E-02)	3.5E-05 (1.3E-03)	5.5E-04 (2.0E-02)	1.4E-05 (5.3E-04)
AO	2	PWR	6.3E-01 (2.3E+01)	4.6E+00 (1.7E+02)	3.5E-04 (1.3E-02)	8.1E-02 (3.0E+00)	2.5E-03 (9.3E-02)	1.8E-05 (6.7E-04)	3.5E-04 (1.3E-02)	3.9E-08 (1.5E-06)
AK	1	PWR	2.6E+00 (9.6E+01)	1.4E+01 (5.0E+02)	1.2E-03 (4.5E-02)	8.8E-02 (3.2E+00)	8.8E-03 (3.3E-01)	1.1E-05 (3.9E-04)	1.1E-02 (4.1E-01)	0.0E+00 (0.0E+00)
AP	2	PWR	4.5E-01 (1.7E+01)	1.4E+00 (5.1E+01)	1.2E-03 (4.3E-02)	8.9E-02 (3.3E+00)	2.4E-03 (9.0E-02)	4.4E-05 (1.6E-03)	1.9E-05 (7.1E-04)	7.6E-13 (2.8E-11)
BA	2	PWR	3.9E-01 (1.4E+01)	6.6E-01 (2.4E+01)	2.0E-04 (7.5E-03)	9.4E-02 (3.5E+00)	1.1E-02 (4.1E-01)	1.3E-05 (4.7E-04)	4.0E-03 (1.5E-01)	2.7E-06 (1.0E-04)
CK	2	PWR	1.8E+00 (6.7E+01)	3.8E+00 (1.4E+02)	6.3E-04 (2.3E-02)	1.7E-01 (6.1E+00)	1.4E-02 (5.3E-01)	2.7E-05 (1.0E-03)	2.3E-04 (8.3E-03)	1.4E-06 (5.3E-05)
AQ	3	PWR	9.3E-02 (3.4E+00)	1.1E+00 (4.0E+01)	2.7E-03 (1.0E-01)	2.0E-01 (7.3E+00)	2.3E-03 (8.7E-02)	4.2E-05 (1.5E-03)	5.8E-04 (2.1E-02)	1.7E-06 (6.4E-05)
CL	2	PWR	1.1E+00 (4.2E+01)	3.7E+00 (1.4E+02)	3.7E-03 (1.4E-01)	2.0E-01 (7.3E+00)	1.3E-03 (4.7E-02)	1.1E-04 (4.2E-03)	1.5E-03 (5.4E-02)	4.0E-05 (1.5E-03)
AE	1	PWR	2.4E-02 (8.9E-01)	2.3E-01 (8.5E+00)	7.3E-04 (2.7E-02)	2.8E-01 (1.0E+01)	3.6E-03 (1.3E-01)	4.4E-06 (1.6E-04)	8.1E-05 (3.0E-03)	2.4E-08 (8.7E-07)
BG	2	PWR	3.3E-01 (1.2E+01)	6.0E-01 (2.2E+01)	1.1E-03 (3.9E-02)	3.1E-01 (1.1E+01)	5.4E-03 (2.0E-01)	1.4E-05 (5.1E-04)	2.2E-04 (8.3E-03)	2.0E-06 (7.4E-05)
BJ	2	PWR	3.0E-01 (1.1E+01)	7.9E-01 (2.9E+01)	9.5E-04 (3.5E-02)	4.4E-01 (1.6E+01)	3.0E-03 (1.1E-01)	4.6E-05 (1.7E-03)	4.7E-04 (1.7E-02)	4.3E-06 (1.6E-04)

Table A-22
Average 10CFR61 Radionuclide Concentrations in Resin Waste In PWR Plants (Activities in Curies/m³ corresponding value in GBq/m³ shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
CB	1	PWR	4.9E-01 (1.8E+01)	2.7E+00 (1.0E+02)	2.9E-03 (1.1E-01)	4.9E-01 (1.8E+01)	4.0E-02 (1.5E+00)	7.2E-04 (2.6E-02)	8.0E-03 (3.0E-01)	2.2E-04 (8.1E-03)
AZ	2	PWR	6.7E-01 (2.5E+01)	1.1E+00 (3.9E+01)	1.8E-03 (6.5E-02)	7.2E-01 (2.7E+01)	2.6E-02 (9.7E-01)	1.4E-05 (5.3E-04)	3.6E-04 (1.3E-02)	1.5E-06 (5.5E-05)
BL	1	PWR	1.2E+00 (4.6E+01)	9.4E+00 (3.5E+02)	1.5E-03 (5.5E-02)	7.9E-01 (2.9E+01)	5.2E-03 (1.9E-01)	5.4E-06 (2.0E-04)	0.0E+00 (0.0E+00)	1.6E-08 (5.8E-07)
AN	2	PWR	8.7E+00 (3.2E+02)	2.4E+01 (8.9E+02)	7.3E-02 (2.7E+00)	7.9E-01 (2.9E+01)	4.0E-03 (1.5E-01)	2.0E-04 (7.4E-03)	1.8E-03 (6.7E-02)	8.8E-06 (3.3E-04)
AL	2	PWR	5.0E-01 (1.9E+01)	1.6E+00 (6.0E+01)	4.2E-03 (1.5E-01)	1.1E+00 (4.1E+01)	5.9E-03 (2.2E-01)	2.5E-04 (9.2E-03)	1.5E-03 (5.6E-02)	2.0E-06 (7.3E-05)
AA	2	PWR	6.1E-01 (2.2E+01)	4.9E+00 (1.8E+02)	3.5E-03 (1.3E-01)	1.4E+00 (5.0E+01)	2.6E-01 (9.5E+00)	1.2E-04 (4.4E-03)	4.0E-04 (1.5E-02)	8.2E-07 (3.0E-05)
CG	1	PWR	1.9E+00 (7.0E+01)	1.0E+01 (3.8E+02)	4.9E-03 (1.8E-01)	2.2E+00 (8.2E+01)	9.1E-03 (3.4E-01)	7.0E-05 (2.6E-03)	1.5E-03 (5.7E-02)	7.0E-06 (2.6E-04)
AM	2	PWR	2.8E+00 (1.0E+02)	7.3E+00 (2.7E+02)	4.1E-03 (1.5E-01)	3.0E+00 (1.1E+02)	1.7E-02 (6.4E-01)	8.1E-05 (3.0E-03)	8.7E-04 (3.2E-02)	3.4E-06 (1.3E-04)
BQ	2	PWR	1.7E+00 (6.4E+01)	4.6E+00 (1.7E+02)	2.2E-03 (8.2E-02)	3.4E+00 (1.3E+02)	7.5E-02 (2.8E+00)	2.6E-05 (9.6E-04)	9.8E-04 (3.6E-02)	4.0E-06 (1.5E-04)
AB	1	PWR	2.0E+00 (7.4E+01)	6.0E+00 (2.2E+02)	8.3E-02 (3.1E+00)	4.9E+00 (1.8E+02)	1.0E-02 (3.8E-01)	9.0E-04 (3.3E-02)	6.6E-03 (2.4E-01)	1.6E-05 (6.0E-04)

Table A-22
Average 10CFR61 Radionuclide Concentrations in Resin Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AG	1	PWR	8.6E-01 (3.2E+01)	2.5E+00 (9.3E+01)	1.9E-02 (6.8E-01)	5.0E+00 (1.8E+02)	3.1E-02 (1.2E+00)	3.1E-04 (1.1E-02)	9.0E-03 (3.3E-01)	6.0E-05 (2.2E-03)
AY	1	PWR	1.4E+00 (5.1E+01)	4.4E+00 (1.6E+02)	2.1E-02 (7.7E-01)	8.1E+00 (3.0E+02)	1.7E-02 (6.2E-01)	1.4E-04 (5.1E-03)	8.7E-04 (3.2E-02)	2.8E-05 (1.0E-03)
BS	1	PWR	2.4E+00 (8.7E+01)	3.9E+00 (1.4E+02)	7.1E-02 (2.6E+00)	1.4E+01 (5.3E+02)	2.2E-02 (8.3E-01)	7.4E-04 (2.7E-02)	7.4E-03 (2.7E-01)	6.0E-05 (2.2E-03)
AT	2	PWR	2.2E+00 (8.2E+01)	9.1E+00 (3.4E+02)	5.0E-02 (1.9E+00)	1.7E+01 (6.2E+02)	5.9E-03 (2.2E-01)	1.2E-03 (4.6E-02)	2.9E-02 (1.1E+00)	3.6E-04 (1.3E-02)

For filter waste in both PWRs and BWRs the Class A classification is not consistently controlled by one or two radionuclides. The data suggest that both the sum-of-the-fractions for 10CFR61 Tables 1 and 2 control the classification, with different radionuclides in each dominating the sum-of-the-fractions. For the following sorts, Cs-137 was used for the BWRs and Ni-63 for the PWRs since they appear to dominate in most of the sum-of-the-fractions for filter waste. Table A-23 shows the average concentrations over four years of the 10CFR61 radionuclides in BWR filter waste in the individual plants.

Table A-23
Average 10CFR61 Radionuclide Concentrations in Filter Waste In BWR Plants (Activities in Curies/m³ corresponding value in GBq/m³ shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AS	1	BWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BP	1	BWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BD	2	BWR	2.7E-01 (1.0E+01)	4.5E-03 (1.7E-01)	1.2E-05 (4.6E-04)	3.7E-03 (1.4E-01)	2.9E-04 (1.1E-02)	2.6E-06 (9.8E-05)	6.2E-05 (2.3E-03)	2.8E-07 (1.0E-05)
AR	1	BWR	1.3E+01 (4.7E+02)	5.9E-02 (2.2E+00)	1.2E-04 (4.3E-03)	4.0E-03 (1.5E-01)	4.2E-04 (1.6E-02)	2.1E-05 (7.7E-04)	4.2E-04 (1.6E-02)	2.3E-06 (8.4E-05)
BE	2	BWR	3.3E-01 (1.2E+01)	1.4E-02 (5.1E-01)	1.7E-04 (6.3E-03)	8.4E-03 (3.1E-01)	4.5E-04 (1.7E-02)	1.8E-05 (6.6E-04)	1.4E-06 (5.0E-05)	1.2E-05 (4.3E-04)
AC	1	BWR	3.0E+01 (1.1E+03)	8.8E-01 (3.3E+01)	1.1E-03 (4.1E-02)	1.3E-02 (4.9E-01)	2.5E-03 (9.4E-02)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AW	1	BWR	8.0E-01 (3.0E+01)	1.1E-01 (4.1E+00)	1.1E-03 (4.0E-02)	1.5E-02 (5.5E-01)	3.0E-03 (1.1E-01)	1.0E-03 (3.8E-02)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AV	1	BWR	1.3E-01 (4.8E+00)	7.2E-03 (2.6E-01)	3.1E-04 (1.1E-02)	1.9E-02 (7.1E-01)	2.3E-04 (8.5E-03)	1.9E-05 (7.0E-04)	0.0E+00 (0.0E+00)	3.0E-06 (1.1E-04)
BU	2	BWR	1.0E+01 (3.8E+02)	2.0E-01 (7.5E+00)	6.0E-04 (2.2E-02)	2.4E-02 (8.9E-01)	2.4E-02 (8.8E-01)	2.0E-05 (7.3E-04)	5.1E-04 (1.9E-02)	1.4E-06 (5.2E-05)
BC	2	BWR	4.2E+00 (1.6E+02)	8.6E-02 (3.2E+00)	1.2E-03 (4.3E-02)	4.3E-02 (1.6E+00)	3.9E-04 (1.4E-02)	3.0E-04 (1.1E-02)	1.2E-02 (4.6E-01)	4.0E-04 (1.5E-02)
AX	1	BWR	1.2E+00 (4.4E+01)	3.8E-02 (1.4E+00)	1.0E-04 (3.8E-03)	5.2E-02 (1.9E+00)	8.8E-03 (3.3E-01)	2.4E-05 (8.7E-04)	3.8E-04 (1.4E-02)	1.4E-06 (5.2E-05)

Table A-23
Average 10CFR61 Radionuclide Concentrations in Filter Waste In BWR Plants (Activities in Curies/m³ corresponding value in GBq/m³ shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AU	1	BWR	1.0E+01 (3.7E+02)	3.7E-01 (1.4E+01)	0.0E+00 (0.0E+00)	5.3E-02 (2.0E+00)	6.6E-02 (2.4E+00)	7.0E-04 (2.6E-02)	9.5E-03 (3.5E-01)	2.4E-05 (8.7E-04)
BV	2	BWR	5.8E-01 (2.1E+01)	1.2E-01 (4.3E+00)	3.9E-04 (1.5E-02)	7.5E-02 (2.8E+00)	8.7E-04 (3.2E-02)	6.6E-06 (2.4E-04)	8.1E-05 (3.0E-03)	1.2E-06 (4.3E-05)
BF	1	BWR	1.1E+01 (3.9E+02)	6.9E-01 (2.6E+01)	1.1E-03 (4.2E-02)	1.3E-01 (4.6E+00)	1.2E-01 (4.4E+00)	3.0E-04 (1.1E-02)	4.4E-03 (1.6E-01)	2.5E-04 (9.1E-03)
AD	1	BWR	7.1E-01 (2.6E+01)	3.0E-02 (1.1E+00)	3.1E-03 (1.2E-01)	5.1E-01 (1.9E+01)	1.1E-03 (3.9E-02)	2.2E-04 (8.0E-03)	2.2E-03 (8.0E-02)	5.2E-05 (1.9E-03)
AH	2	BWR	5.4E+00 (2.0E+02)	1.7E-01 (6.2E+00)	5.5E-03 (2.0E-01)	7.1E-01 (2.6E+01)	3.7E-03 (1.4E-01)	3.1E-04 (1.1E-02)	1.7E-03 (6.1E-02)	6.3E-05 (2.3E-03)
BB	2	BWR	6.0E+00 (2.2E+02)	1.0E+00 (3.7E+01)	7.7E-02 (2.9E+00)	4.7E+00 (1.7E+02)	1.1E-03 (4.0E-02)	9.2E-03 (3.4E-01)	3.2E-02 (1.2E+00)	7.1E-04 (2.6E-02)

The companion table for PWRs is shown in Table A-24.

Table A-24
Average 10CFR61 Radionuclide Concentrations in Filter Waste In PWR Plants (Activities in Curies/m³ corresponding value in GBq/m³ shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AB	1	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AE	1	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AI	1	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AM	2	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AY	1	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BJ	2	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BQ	2	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BS	1	PWR	1.0E-01 (3.7E+00)	0.0E+00 (0.0E+00)	3.6E-03 (1.3E-01)	1.9E-03 (7.2E-02)	7.5E-02 (2.8E+00)	9.4E-05 (3.5E-03)	1.9E-04 (7.1E-03)	4.0E-06 (1.5E-04)
AL	2	PWR	8.6E-02 (3.2E+00)	1.4E-01 (5.3E+00)	1.4E-04 (5.1E-03)	3.5E-02 (1.3E+00)	1.9E-03 (6.8E-02)	8.3E-05 (3.1E-03)	8.7E-04 (3.2E-02)	3.4E-06 (1.3E-04)
AG	1	PWR	1.8E+00 (6.7E+01)	7.7E-01 (2.9E+01)	2.5E-04 (9.2E-03)	3.1E-03 (1.1E-01)	3.4E-02 (1.2E+00)	9.3E-04 (3.4E-02)	8.2E-03 (3.0E-01)	1.5E-04 (5.4E-03)
BG	2	PWR	1.6E+00 (5.8E+01)	8.8E-01 (3.3E+01)	3.7E-05 (1.4E-03)	1.1E-02 (4.0E-01)	1.6E-01 (6.0E+00)	1.1E-03 (3.9E-02)	2.5E-02 (9.1E-01)	6.4E-04 (2.4E-02)

Table A-24
Average 10CFR61 Radionuclide Concentrations in Filter Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BA	2	PWR	2.0E+00 (7.3E+01)	2.0E+00 (7.3E+01)	9.0E-05 (3.3E-03)	2.7E-02 (1.0E+00)	6.1E-02 (2.3E+00)	3.9E-05 (1.4E-03)	1.1E-03 (4.2E-02)	7.3E-06 (2.7E-04)
AA	2	PWR	4.4E-01 (1.6E+01)	3.7E+00 (1.4E+02)	3.3E-04 (1.2E-02)	6.3E-02 (2.3E+00)	2.6E-01 (9.7E+00)	3.7E-06 (1.4E-04)	5.5E-05 (2.0E-03)	2.0E-06 (7.2E-05)
CB	1	PWR	1.6E+00 (6.1E+01)	4.0E+00 (1.5E+02)	1.3E-03 (4.8E-02)	1.5E-01 (5.6E+00)	4.1E-02 (1.5E+00)	7.8E-04 (2.9E-02)	3.9E-03 (1.5E-01)	1.4E-04 (5.1E-03)
CL	2	PWR	1.6E+00 (5.9E+01)	4.2E+00 (1.5E+02)	2.2E-05 (8.0E-04)	1.1E+00 (4.2E+01)	1.1E+00 (4.2E+01)	8.4E-05 (3.1E-03)	1.3E-03 (4.8E-02)	1.9E-08 (7.1E-07)
AQ	3	PWR	9.7E-01 (3.6E+01)	5.0E+00 (1.9E+02)	2.5E-04 (9.3E-03)	4.6E+00 (1.7E+02)	8.1E-03 (3.0E-01)	1.4E-03 (5.0E-02)	1.4E-02 (5.3E-01)	9.0E-04 (3.3E-02)
AK	1	PWR	4.4E+00 (1.6E+02)	6.9E+00 (2.5E+02)	0.0E+00 (0.0E+00)	3.7E-02 (1.4E+00)	2.8E-05 (1.1E-03)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AZ	2	PWR	2.5E+00 (9.4E+01)	7.1E+00 (2.6E+02)	3.1E-04 (1.1E-02)	1.4E-01 (5.2E+00)	2.8E-01 (1.0E+01)	6.3E-05 (2.3E-03)	8.7E-04 (3.2E-02)	4.0E-07 (1.5E-05)
AP	2	PWR	8.3E+00 (3.1E+02)	7.5E+00 (2.8E+02)	9.8E-04 (3.6E-02)	1.2E-03 (4.6E-02)	8.6E-02 (3.2E+00)	2.4E-03 (8.8E-02)	1.7E-02 (6.1E-01)	1.1E-07 (4.1E-06)
CK	2	PWR	8.5E+00 (3.1E+02)	8.7E+00 (3.2E+02)	1.6E-04 (6.1E-03)	2.7E-01 (1.0E+01)	9.2E-01 (3.4E+01)	2.1E-03 (7.6E-02)	2.6E-02 (9.7E-01)	1.6E-07 (6.0E-06)
BL	1	PWR	4.1E+00 (1.5E+02)	1.2E+01 (4.6E+02)	6.7E-04 (2.5E-02)	1.8E-01 (6.7E+00)	5.2E-01 (1.9E+01)	2.9E-05 (1.1E-03)	8.7E-04 (3.2E-02)	1.4E-06 (5.3E-05)
AN	2	PWR	1.2E+01 (4.5E+02)	1.3E+01 (4.8E+02)	8.6E-03 (3.2E-01)	6.9E-02 (2.6E+00)	9.4E-01 (3.5E+01)	2.1E-03 (7.9E-02)	4.4E-02 (1.6E+00)	7.3E-04 (2.7E-02)

Average 10CFR61 Radionuclide Concentrations in Filter Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AO	2	PWR	2.2E+01 (8.0E+02)	2.0E+01 (7.5E+02)	0.0E+00 (0.0E+00)	3.8E-01 (1.4E+01)	3.9E+00 (1.4E+02)	0.0E+00 (0.0E+00)	2.3E-02 (8.6E-01)	0.0E+00 (0.0E+00)
CG	1	PWR	1.1E+01 (4.2E+02)	2.3E+01 (8.5E+02)	2.7E-03 (9.9E-02)	2.7E-01 (9.8E+00)	4.3E+00 (1.6E+02)	8.6E-05 (3.2E-03)	6.4E-03 (2.4E-01)	2.8E-08 (1.0E-06)
AT	2	PWR	6.5E+00 (2.4E+02)	2.4E+01 (8.8E+02)	3.9E-02 (1.4E+00)	3.5E+01 (1.3E+03)	1.7E-02 (6.4E-01)	6.6E-04 (2.4E-02)	1.9E-02 (6.9E-01)	4.5E-04 (1.7E-02)

For DAW in both PWRs and BWRs there were no plants that, on average, where the Class A limit was exceeded and therefore the concept of a controlling radionuclide would not apply. However, for purposes of presentation, the concentrations for both PWRs and BWRs were sorted based on the concentrations of Cs-137. Table A-25 shows the average concentrations over four years of the 10 CFR 61 radionuclides in BWR DAW waste in the individual plants.

Table A-25
Average 10 CFR 61 Radionuclide Concentrations in DAW Waste In BWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AC	1	BWR	5.1E-04 (1.9E-02)	2.5E-05 (9.3E-04)	1.9E-08 (7.0E-07)	4.6E-07 (1.7E-05)	3.9E-07 (1.5E-05)	1.0E-09 (3.7E-08)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BE	2	BWR	6.8E-04 (2.5E-02)	1.8E-04 (6.5E-03)	1.2E-07 (4.6E-06)	3.0E-06 (1.1E-04)	7.9E-07 (2.9E-05)	2.0E-09 (7.5E-08)	9.0E-09 (3.3E-07)	2.7E-10 (1.0E-08)
AW	1	BWR	5.5E-04 (2.0E-02)	3.3E-06 (1.2E-04)	6.2E-08 (2.3E-06)	4.2E-06 (1.5E-04)	1.3E-04 (4.8E-03)	2.1E-09 (7.7E-08)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BU	2	BWR	8.8E-04 (3.2E-02)	4.3E-05 (1.6E-03)	4.6E-10 (1.7E-08)	4.9E-06 (1.8E-04)	9.5E-07 (3.5E-05)	7.3E-08 (2.7E-06)	8.7E-07 (3.2E-05)	0.0E+00 (0.0E+00)
BC	2	BWR	1.8E-03 (6.5E-02)	7.0E-04 (2.6E-02)	1.3E-06 (4.7E-05)	1.2E-05 (4.5E-04)	7.4E-06 (2.8E-04)	7.9E-08 (2.9E-06)	3.3E-06 (1.2E-04)	1.7E-08 (6.3E-07)
AS	1	BWR	1.4E-04 (5.0E-03)	1.3E-05 (4.7E-04)	9.0E-07 (3.3E-05)	1.7E-05 (6.1E-04)	3.4E-04 (1.2E-02)	5.8E-09 (2.1E-07)	9.0E-08 (3.3E-06)	7.8E-09 (2.9E-07)
AU	1	BWR	3.7E-04 (1.4E-02)	4.4E-04 (1.6E-02)	2.8E-09 (1.0E-07)	2.0E-05 (7.5E-04)	1.1E-06 (4.0E-05)	1.6E-07 (5.9E-06)	4.6E-07 (1.7E-05)	9.3E-09 (3.4E-07)
AV	1	BWR	2.6E-04 (9.6E-03)	1.0E-05 (3.8E-04)	2.6E-07 (9.4E-06)	2.5E-05 (9.2E-04)	5.8E-04 (2.1E-02)	3.5E-08 (1.3E-06)	1.3E-07 (4.9E-06)	1.1E-08 (4.2E-07)
BV	2	BWR	1.6E-03 (6.0E-02)	2.5E-04 (9.3E-03)	2.4E-09 (9.0E-08)	5.5E-05 (2.0E-03)	3.0E-05 (1.1E-03)	3.2E-09 (1.2E-07)	1.9E-08 (7.2E-07)	6.7E-12 (2.5E-10)
AH	2	BWR	3.8E-04 (1.4E-02)	1.6E-05 (6.0E-04)	2.8E-07 (1.1E-05)	5.8E-05 (2.1E-03)	5.2E-07 (1.9E-05)	7.6E-08 (2.8E-06)	4.6E-07 (1.7E-05)	6.3E-09 (2.3E-07)
AX	1	BWR	2.6E-03 (9.5E-02)	6.3E-05 (2.3E-03)	1.3E-05 (4.7E-04)	9.2E-05 (3.4E-03)	1.3E-04 (4.8E-03)	1.9E-07 (7.0E-06)	2.8E-05 (1.0E-03)	8.1E-08 (3.0E-06)

Table A-25
Average 10 CFR 61 Radionuclide Concentrations in DAW Waste In BWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses) (continued)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BF	1	BWR	4.0E-03 (1.5E-01)	5.6E-05 (2.1E-03)	6.3E-07 (2.3E-05)	9.9E-05 (3.7E-03)	2.5E-05 (9.1E-04)	1.1E-07 (4.1E-06)	6.7E-07 (2.5E-05)	9.9E-08 (3.6E-06)
BD	2	BWR	3.6E-03 (1.3E-01)	1.2E-04 (4.3E-03)	3.1E-06 (1.2E-04)	2.1E-04 (7.6E-03)	5.6E-05 (2.1E-03)	4.7E-08 (1.7E-06)	1.3E-06 (4.8E-05)	3.3E-09 (1.2E-07)
BP	1	BWR	1.0E-03 (3.8E-02)	5.9E-05 (2.2E-03)	3.0E-06 (1.1E-04)	2.7E-04 (9.9E-03)	1.3E-05 (4.7E-04)	9.5E-07 (3.5E-05)	5.7E-06 (2.1E-04)	8.3E-08 (3.1E-06)
AD	1	BWR	2.2E-04 (8.0E-03)	5.1E-06 (1.9E-04)	7.6E-07 (2.8E-05)	2.7E-04 (9.9E-03)	1.1E-05 (4.1E-04)	4.3E-07 (1.6E-05)	3.2E-06 (1.2E-04)	7.5E-08 (2.8E-06)
AR	1	BWR	2.7E-02 (1.0E+00)	5.2E-04 (1.9E-02)	6.9E-06 (2.6E-04)	2.8E-04 (1.0E-02)	3.7E-05 (1.4E-03)	2.3E-06 (8.3E-05)	9.0E-07 (3.3E-05)	0.0E+00 (0.0E+00)
BB	2	BWR	1.1E-03 (4.1E-02)	3.5E-04 (1.3E-02)	1.5E-05 (5.6E-04)	5.2E-04 (1.9E-02)	9.7E-07 (3.6E-05)	2.6E-06 (9.5E-05)	8.1E-06 (3.0E-04)	7.8E-08 (2.9E-06)

The corresponding PWR concentration data are shown in Table A-26.

Table A-26
Average 10 CFR 61 Radionuclide Concentrations in DAW Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BL	1	PWR	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AI	1	PWR	2.3E-06 (8.6E-05)	3.1E-06 (1.1E-04)	5.5E-09 (2.0E-07)	1.7E-07 (6.1E-06)	4.5E-08 (1.6E-06)	7.5E-09 (2.8E-07)	6.9E-08 (2.5E-06)	2.0E-08 (7.4E-07)
BQ	2	PWR	3.9E-05 (1.4E-03)	5.6E-05 (2.1E-03)	8.9E-09 (3.3E-07)	6.3E-07 (2.3E-05)	4.6E-06 (1.7E-04)	3.7E-09 (1.4E-07)	5.1E-08 (1.9E-06)	1.1E-09 (4.2E-08)
AK	1	PWR	5.3E-04 (2.0E-02)	5.0E-04 (1.8E-02)	0.0E+00 (0.0E+00)	3.2E-06 (1.2E-04)	1.1E-04 (3.9E-03)	4.5E-09 (1.7E-07)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
CG	1	PWR	2.2E-04 (8.3E-03)	3.2E-04 (1.2E-02)	0.0E+00 (0.0E+00)	4.7E-06 (1.8E-04)	2.7E-05 (1.0E-03)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
BA	2	PWR	4.3E-04 (1.6E-02)	4.2E-04 (1.5E-02)	4.1E-06 (1.5E-04)	8.5E-06 (3.1E-04)	1.5E-05 (5.6E-04)	3.9E-07 (1.4E-05)	2.0E-06 (7.5E-05)	9.4E-08 (3.5E-06)
AP	2	PWR	5.4E-04 (2.0E-02)	9.9E-04 (3.7E-02)	5.6E-07 (2.1E-05)	6.2E-05 (2.3E-03)	1.1E-03 (4.2E-02)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AB	1	PWR	5.7E-05 (2.1E-03)	8.8E-05 (3.3E-03)	6.0E-09 (2.2E-07)	8.9E-05 (3.3E-03)	6.4E-07 (2.4E-05)	3.6E-08 (1.3E-06)	2.5E-07 (9.3E-06)	3.8E-08 (1.4E-06)
CK	2	PWR	5.7E-04 (2.1E-02)	6.9E-04 (2.6E-02)	1.9E-06 (7.0E-05)	1.0E-04 (3.7E-03)	2.7E-05 (9.8E-04)	3.6E-07 (1.3E-05)	4.5E-06 (1.6E-04)	1.3E-09 (4.7E-08)
AZ	2	PWR	6.7E-04 (2.5E-02)	1.6E-03 (5.9E-02)	6.3E-08 (2.3E-06)	1.2E-04 (4.4E-03)	6.2E-05 (2.3E-03)	1.4E-08 (5.1E-07)	1.9E-07 (7.0E-06)	7.5E-10 (2.8E-08)
AG	1	PWR	5.5E-04 (2.0E-02)	7.8E-04 (2.9E-02)	5.0E-06 (1.8E-04)	1.4E-04 (5.0E-03)	2.7E-05 (1.0E-03)	9.1E-07 (3.4E-05)	1.8E-05 (6.5E-04)	1.2E-07 (4.6E-06)

Average 10 CFR 61 Radionuclide Concentrations in DAW Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
BG	2	PWR	2.1E-04 (7.8E-03)	1.8E-04 (6.7E-03)	5.8E-07 (2.1E-05)	1.6E-04 (5.9E-03)	1.0E-05 (3.7E-04)	1.2E-07 (4.4E-06)	3.0E-06 (1.1E-04)	1.5E-08 (5.4E-07)
BJ	2	PWR	3.2E-04 (1.2E-02)	3.5E-04 (1.3E-02)	0.0E+00 (0.0E+00)	1.7E-04 (6.2E-03)	4.4E-05 (1.6E-03)	8.3E-08 (3.1E-06)	3.0E-06 (1.1E-04)	1.6E-08 (6.0E-07)
CL	2	PWR	5.3E-04 (2.0E-02)	1.4E-03 (5.1E-02)	4.7E-07 (1.8E-05)	1.8E-04 (6.5E-03)	1.2E-04 (4.3E-03)	3.3E-07 (1.2E-05)	1.2E-07 (4.4E-06)	3.0E-08 (1.1E-06)
AA	2	PWR	2.2E-04 (8.1E-03)	3.2E-04 (1.2E-02)	2.4E-07 (9.0E-06)	2.9E-04 (1.1E-02)	1.2E-04 (4.3E-03)	1.3E-08 (5.0E-07)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AL	2	PWR	1.4E-03 (5.2E-02)	1.1E-03 (3.9E-02)	4.0E-07 (1.5E-05)	3.9E-04 (1.4E-02)	3.2E-05 (1.2E-03)	3.8E-06 (1.4E-04)	1.3E-05 (4.8E-04)	1.6E-09 (6.0E-08)
BS	1	PWR	6.9E-04 (2.6E-02)	4.9E-04 (1.8E-02)	9.2E-06 (3.4E-04)	4.1E-04 (1.5E-02)	1.4E-06 (5.0E-05)	1.8E-06 (6.7E-05)	2.6E-06 (9.5E-05)	3.7E-07 (1.4E-05)
AM	2	PWR	1.1E-03 (3.9E-02)	4.4E-04 (1.6E-02)	1.1E-06 (3.9E-05)	4.8E-04 (1.8E-02)	4.4E-06 (1.6E-04)	4.7E-07 (1.8E-05)	2.8E-06 (1.0E-04)	5.5E-08 (2.0E-06)
AY	1	PWR	3.8E-04 (1.4E-02)	8.6E-04 (3.2E-02)	7.2E-06 (2.7E-04)	6.9E-04 (2.6E-02)	1.5E-04 (5.4E-03)	4.3E-07 (1.6E-05)	1.3E-06 (4.7E-05)	1.6E-07 (6.0E-06)
AT	2	PWR	1.8E-02 (6.7E-01)	5.4E-03 (2.0E-01)	3.3E-05 (1.2E-03)	9.4E-04 (3.5E-02)	2.1E-04 (7.7E-03)	2.7E-05 (9.9E-04)	2.4E-04 (8.7E-03)	1.1E-06 (3.9E-05)
AE	1	PWR	3.9E-05 (1.4E-03)	3.7E-04 (1.4E-02)	7.3E-05 (2.7E-03)	9.9E-04 (3.7E-02)	1.7E-05 (6.3E-04)	2.6E-07 (9.6E-06)	2.9E-06 (1.1E-04)	2.3E-08 (8.6E-07)
CB	1	PWR	2.2E-03 (8.3E-02)	2.2E-03 (8.1E-02)	1.3E-06 (4.7E-05)	1.3E-03 (4.7E-02)	4.6E-04 (1.7E-02)	4.6E-07 (1.7E-05)	8.0E-07 (2.9E-05)	1.5E-07 (5.5E-06)
AQ	3	PWR	3.8E-04 (1.4E-02)	3.9E-03 (1.5E-01)	0.0E+00 (0.0E+00)	2.4E-03 (9.0E-02)	1.6E-04 (6.0E-03)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)

Average 10 CFR 61 Radionuclide Concentrations in DAW Waste In PWR Plants (Activities in Curies/m^3 corresponding value in GBq/m^3 shown in parentheses)

Plant Designation	# of Units	Reactor Type	Co-60	Ni-63	Sr-90	CS-137	C-14	TRU	Pu-241	Cm-242
AO	2	PWR	2.3E-01 (8.5E+00)	4.0E-01 (1.5E+01)	5.6E-03 (2.1E-01)	3.6E-03 (1.3E-01)	8.9E-02 (3.3E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)	0.0E+00 (0.0E+00)
AN	2	PWR	2.6E-03 (9.4E-02)	1.5E-03 (5.6E-02)	2.9E-06 (1.1E-04)	3.7E-03 (1.4E-01)	9.5E-05 (3.5E-03)	1.3E-06 (4.7E-05)	1.5E-05 (5.7E-04)	3.0E-07 (1.1E-05)

Based on the average concentrations of the 10 CFR 61 radionuclides presented above for each waste type and for each individual plant, the 10 CFR 61 Table 1 and Table 2 sum-of-the fractions were determined for each individual plant for each of the three waste steams. These sum-of-the-fractions are, in effect, a classification of the entire waste steam generated over the four year time span. For resin waste, with a couple of exceptions, the Table 2 sum-of-the fractions will control the Class A classification of the waste. Accordingly, the individual plant sum-of-the-fractions for Table 2 was used to sort the data from lowest to highest as shown in Table A-27.

Table A-27
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in BWR Resin Waste

Plant Designation	# of Units	Reactor Type	Dominant Radionuclide	Table 2 SOF	Table 1 SOF	Dominant Table SOF
BU	2	BWR	Tc-99	6.80E-03	1.32E-01	Table 1
AC	1	BWR	C-14	1.80E-02	1.14E-01	Table 1
AR	1	BWR	Ni-63	3.90E-02	3.83E-02	Table 2
AS	1	BWR	Cs-137	8.11E-02	2.83E-02	Table 2
AD	1	BWR	TRU	1.09E-01	4.72E-01	Table 1
BE	2	BWR	Cs-137	1.63E-01	4.31E-02	Table 2
BD	2	BWR	Cs-137	2.24E-01	1.03E-01	Table 2
AX	1	BWR	Cs-137	2.31E-01	3.69E-02	Table 2
AW	1	BWR	Cs-137	2.46E-01	7.70E-02	Table 2
AH	2	BWR	Cs-137	4.40E-01	2.92E-02	Table 2
BP	1	BWR	Cs-137	4.74E-01	3.89E-02	Table 2
BV	2	BWR	Cs-137	5.86E-01	7.63E-02	Table 2
BC	2	BWR	Cs-137	6.40E-01	3.78E-01	Table 2
BF	1	BWR	Cs-137	7.09E-01	7.13E-02	Table 2
BB	2	BWR	Cs-137	7.17E-01	1.93E-01	Table 2
AV	1	BWR	Cs-137	9.70E-01	6.61E-02	Table 2
AU	1	BWR	Cs-137	1.98E+00	1.31E-01	Table 2

The corresponding table for PWRs is given in Table A-28.

Table A-28
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in PWR Resin Waste

Plant Designation	# of Units	Reactor Type	Dominant Radionuclide	Table 2 SOF	Table 1 SOF	Dominant Table SOF
AI	1	PWR	Ni-63	5.24E-02	1.25E-02	Table 2
BA	2	PWR	Ni-63	2.87E-01	8.74E-02	Table 2
AE	1	PWR	Cs-137	3.64E-01	1.74E-02	Table 2
BG	2	PWR	Cs-137	5.05E-01	2.83E-02	Table 2
AP	2	PWR	Ni-63	5.12E-01	1.70E-02	Table 2
AQ	3	PWR	Ni-63	5.72E-01	2.01E-02	Table 2
BJ	2	PWR	Cs-137	6.88E-01	2.32E-02	Table 2
AZ	2	PWR	Cs-137	1.06E+00	1.24E-01	Table 2
CK	2	PWR	Ni-63	1.26E+00	7.12E-02	Table 2
CL	2	PWR	Ni-63	1.33E+00	3.00E-02	Table 2
CB	1	PWR	Ni-63	1.34E+00	3.50E-01	Table 2
AO	2	PWR	Ni-63	1.40E+00	1.66E-02	Table 2
AL	2	PWR	Cs-137	1.67E+00	7.71E-02	Table 2
AA	2	PWR	Ni-63	2.83E+00	1.20E+00	Table 2
BL	1	PWR	Ni-63	3.52E+00	2.45E-02	Table 2
AK	1	PWR	Ni-63	3.97E+00	1.14E-01	Table 2
BQ	2	PWR	Cs-137	4.81E+00	3.52E-01	Table 2
AM	2	PWR	Cs-137	5.16E+00	9.53E-02	Table 2
CG	1	PWR	Ni-63	5.32E+00	5.95E-02	Table 2
AG	1	PWR	Cs-137	6.15E+00	2.28E-01	Table 2
AB	1	PWR	Cs-137	8.74E+00	1.85E-01	Table 2
AN	2	PWR	Ni-63	9.52E+00	6.23E-02	Table 2
AY	1	PWR	Cs-137	9.87E+00	9.95E-02	Table 2
BS	1	PWR	Cs-137	1.73E+01	2.49E-01	Table 2
AT	2	PWR	Cs-137	2.06E+01	3.77E-01	Table 2

The classification of filter waste is somewhat more complex than resin waste. For example, in BWRS there are no plants that where the sum-of-the-fractions exceeds that Class A limit based on the average concentrations in the filter waste stream. The split between Table 1 and Table 2 dominating the classification is about equal between the two tables in BWRs. This is likewise true for PWRs, with Ni-63 controlling in Table 2 and Tc-99 controlling in Table 1. Table A-29 presents the classification for the BWR filter waste stream.

Table A-29
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in BWR Filter Waste

Plant Designation	Number of Units	Reactor Type		Table 2 SOF	Table 1 SOF	Dominant Table SOF
AC	1	BWR	Ni-63	3.37E-01	1.16E-02	Table 2
AD	1	BWR	Cs-137	5.98E-01	6.44E-02	Table 2
AH	2	BWR	Cs-137	9.04E-01	6.59E-02	Table 2
AR	1	BWR	Ni-63	4.19E-02	2.12E-02	Table 2
AS	1	BWR				
AU	1	BWR	Ni-63	1.72E-01	6.94E-01	Table 1
AV	1	BWR	Cs-137	2.92E-02	1.67E-02	Table 2
AW	1	BWR	Ni-63	7.46E-02	1.53E-01	Table 1
AX	1	BWR	Cs-137	6.77E-02	4.93E-02	Table 2
BB	2	BWR	Cs-137	6.90E+00	2.37E+00	Table 2
BC	2	BWR	Cs-137	1.02E-01	1.26E-01	Table 1
BD	2	BWR	Cs-137	5.71E-03	2.61E-03	Table 2
BE	2	BWR	Cs-137	1.70E-02	8.15E-03	Table 2
BF	1	BWR	Ni-63	3.67E-01	5.91E-01	Table 1
BP	1	BWR				
BU	2	BWR	Ni-63	1.12E-01	1.15E-01	Table 1
BV	2	BWR	Cs-137	1.18E-01	5.50E-03	Table 2

The PWR information is given in Table A-30.

Table A-30
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in PWR Filter Waste

Plant Designation	Number of Units	Reactor Type		Table 2 SOF	Table 1 SOF	Dominant Table SOF
AA	2	PWR	Ni-63	1.12E+00	1.20E+00	Table 1
AB	1	PWR				
AE	1	PWR				
AG	1	PWR	Ni-63	2.33E-01	3.76E-01	Table 1
AI	1	PWR				
AK	1	PWR	Ni-63	2.00E+00	1.30E-04	Table 2
AL	2	PWR	Ni-63	7.98E-02	6.53E-02	Table 2
AM	2	PWR				
AN	2	PWR	Ni-63	4.00E+00	5.68E+00	Table 1
AO	2	PWR	Ni-63	6.20E+00	1.81E+01	Table 1
AP	2	PWR	Ni-63	2.18E+00	1.22E+00	Table 2
AQ	3	PWR	Cs-137	6.04E+00	5.48E-01	Table 2
AT	2	PWR	Cs-137	4.23E+01	6.27E-01	Table 2
AY	1	PWR				
AZ	2	PWR	Ni-63	2.17E+00	1.30E+00	Table 2
BA	2	PWR	Ni-63	5.93E-01	2.95E-01	Table 2
BG	2	PWR	Ni-63	2.66E-01	1.43E+00	Table 1
BJ	2	PWR				
BL	1	PWR	Ni-63	3.72E+00	2.42E+00	Table 2
BQ	2	PWR				
BS	1	PWR		9.23E-02	3.69E-01	Table 1
CB	1	PWR	Ni-63	1.32E+00	5.59E-01	Table 2
CG	1	PWR	Ni-63	6.89E+00	1.99E+01	Table 1
CK	2	PWR	Ni-63	2.77E+00	5.43E+00	Table 1
CL	2	PWR	Ni-63	2.33E+00	5.26E+00	Table 1

As was the case for the filter waste, the DAW classification picture is a mixed bag with different 10CFR61 Tables and different radionuclides dominating the Class A classification. In the case of DAW, on average classification is not an issue since for the most part DAW waste does not generally approach the Class A concentration limits. The following Table A-31 and Table A-32 present the classification information for DAW wastes for BWRs and PWRs, respectively.

Table A-31
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in BWR DAW Waste

Plant Designation	Number of Units	Reactor Type	Table 2 Dominant Nuclide	Table 2 SOF	Table 1 SOF	Dominant Table SOF
AC	1	BWR	Ni-63	8.85E-06	2.53E-06	Table 2
AD	1	BWR	Cs-137	2.89E-04	4.57E-04	Table 1
AH	2	BWR	Cs-137	7.04E-05	4.58E-05	Table 2
AR	1	BWR	Cs-137	6.43E-04	5.86E-04	Table 2
AS	1	BWR	Cs-137	4.29E-05	1.54E-03	Table 1
AU	1	BWR	Ni-63	1.46E-04	1.10E-04	Table 2
AV	1	BWR	Cs-137	3.46E-05	2.66E-03	Table 1
AW	1	BWR	Cs-137	7.45E-06	5.97E-04	Table 1
AX	1	BWR	Cs-137	4.29E-04	1.64E-03	Table 1
BB	2	BWR	Cs-137	1.00E-03	1.66E-03	Table 1
BC	2	BWR	Ni-63	2.47E-04	1.88E-04	Table 2
BD	2	BWR	Cs-137	3.22E-04	3.03E-04	Table 2
BE	2	BWR	Ni-63	5.71E-05	5.58E-06	Table 2
BF	1	BWR	Cs-137	1.36E-04	1.76E-04	Table 1
BP	1	BWR	Cs-137	3.61E-04	7.74E-04	Table 1
BU	2	BWR	Ni-63	1.83E-05	1.97E-05	Table 1
BV	2	BWR	Ni-63	1.29E-04	1.40E-04	Table 1

Table A-32
10 CFR 61 Table 1 and 2 Sum-of-the-Fractions Based on Average Radionuclide Concentrations in PWR DAW Waste

Plant Designation	Number of Units	Reactor Type	Table 2 Dominant Nuclide	Table 2 SOF	Table 1 SOF	Dominant Table SOF
AA	2	PWR	Cs-137	3.90E-04	5.41E-04	Table 1
AB	1	PWR	Cs-137	1.15E-04	2.82E-05	Table 2
AE	1	PWR	Cs-137	2.90E-03	2.88E-04	Table 2
AG	1	PWR	Ni-63	4.84E-04	7.70E-04	Table 1
AI	1	PWR	Ni-63	1.18E-06	2.96E-05	Table 1
AK	1	PWR	Ni-63	1.46E-04	4.83E-04	Table 1
AL	2	PWR	Cs-137	7.02E-04	1.77E-03	Table 1
AM	2	PWR	Cs-137	6.29E-04	3.73E-04	Table 2
AN	2	PWR	Cs-137	4.21E-03	1.26E-03	Table 2
AO	2	PWR	Ni-63	2.57E-01	4.09E-01	Table 1
AP	2	PWR	Ni-63	3.60E-04	5.23E-03	Table 1
AQ	3	PWR	Cs-137	3.55E-03	7.40E-04	Table 2
AT	2	PWR	Ni-63	3.33E-03	1.72E-02	Table 1
AY	1	PWR	Cs-137	1.12E-03	9.63E-04	Table 2
AZ	2	PWR	Ni-63	5.77E-04	2.96E-04	Table 2
BA	2	PWR	Ni-63	2.30E-04	3.53E-04	Table 1
BG	2	PWR	Cs-137	2.27E-04	2.31E-04	Table 1
BJ	2	PWR	Cs-137	2.67E-04	3.36E-04	Table 1
BL	1	PWR				
BQ	2	PWR	Ni-63	1.68E-05	2.29E-05	Table 1
BS	1	PWR	Cs-137	7.78E-04	1.26E-03	Table 1
CB	1	PWR	Cs-137	1.93E-03	2.33E-03	Table 1
CG	1	PWR	Ni-63	9.54E-05	1.25E-04	Table 1
CK	2	PWR	Ni-63	3.47E-04	4.66E-04	Table 1
CL	2	PWR	Ni-63	5.86E-04	7.16E-04	Table 1

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