ACNWR-0151

March 31, 2000

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: COMMENTS AND RECOMMENDATIONS ON THE DRAFT FINAL RULE, 10 CFR PART 63, "DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE IN A PROPOSED GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA"

Dear Chairman Meserve:

In this letter we offer our comments on the draft final rule, 10 CFR Part 63, "Disposal of High-Level Radioactive Waste in a Proposed Geologic Repository at Yucca Mountain, Nevada," and the NRC staff draft final responses to public comments on several technical issues addressed in the draft rule (Reference 1). This letter responds to the staff requirements memorandum dated February 1, 2000, requesting the views of the Advisory Committee on Nuclear Waste (ACNW) on the draft final rule by March 31, 2000.

During the ACNW's 114th meeting on November 14–16, 1999, the NRC staff presented a summary of the public comments received on the proposed draft 10 CFR Part 63 and its interim proposed responses to the comments. In addition, during a joint Advisory Committee on Reactor Safeguards (ACRS) and ACNW meeting on January 13-14, 2000, on defense in depth, the NRC staff presented its proposed approach for clarifying the multiple-barrier requirement in the draft high-level radioactive waste (HLW) rule. Since that time, the staff has kept us informed of changes to the draft rule as it has evolved; however, the Committee has not reviewed the ultimate version of the draft final rule that will be forwarded to the Commission.

The following comments are submitted on the staff's proposed response to several specific technical issues addressed in the rule. These issues include the staff's proposed approach to clarify the multiple-barrier requirement and defense-in-depth concept, aspects of design basis events, waste retrievability, human intrusion, performance confirmation, and transportation of HLW.

RECOMMENDATIONS

1. Multiple Barriers — The Committee recommends that a quantitative dose limit not be set in the rule for hypothetical assessments for performance of multiple barriers. The Committee recommends an approach to quantify the contributions of barriers that compares estimated repository performance with and without the benefit of specific barriers. The Committee recommends that the detailed method of analyzing multiple

barriers be limited to the guidance documents, as opposed to being a basic part of the regulation.

2. Performance Confirmation — The Committee agrees with the staff on the need for a repository performance confirmation plan that provides insights on post-closure performance while not compromising design flexibility. The Committee recommends that in its review of the Department of Energy's (DOE's) performance confirmation plan, the NRC staff encourages DOE to design its monitoring program in parallel with the repository design. Optimal placement of monitoring devices should not be precluded.

3. Design Basis Events —The ACNW supports the staff's proposed clarifications, including elimination of the term "design basis event" in the proposed rule to avoid confusion and miscommunication. The Committee recommends that the importance of event sequences in terms of their impact on overall repository performance, that is, on the radiation dose to the critical group, be the principal basis for allocating analysis and investigation resources to ensure the safety of the public and protection of the environment.

4. Human Intrusion — The Committee recommends that the staff avoid the use of surrogate risk values for human intrusion in the regulation. We recommend that the staff compare the results of the hypothetical intruder analyses to the results of the performance assessment analyses. If the staff decides that a license application could be evaluated more easily with a comparison of the results of the hypothetical calculation with a higher dose limit, for example, 1000 mrem (10 mSv) per year, we recommend that this approach be incorporated into the guidance rather than the rule itself.

5. Waste Retrievability — The Committee supports the staff's proposed approach to require DOE to plan for but not to demonstrate that the waste package is retrievable before issuing a license to construct the repository. The Committee believes that waste retrieval does not present an insurmountable technological challenge.

6. Transportation — The ACNW supports the staff's decision not to address transportation in 10 CFR Part 63. The Committee continues to emphasize the need for clarification and improved management of the overall transportation issue as no single agency appears to have the authority to take a total systems approach to address this public policy issue.

General Comments

1. The staff has done an outstanding job of summarizing and responding to the vast number and wide range of public comments received on the proposed draft rule. The ACNW commends the staff for this significant and noteworthy effort.

2. The staff has made considerable progress in its goal of improving public involvement during the past year through its interactions with the public on draft 10 CFR Part 63. We commend the staff for holding multiple workshops in the Yucca Mountain area to solicit input from stakeholders on the proposed rule. We also encourage the staff in its plans to hold follow-on workshops with stakeholders to convey the final resolution and

response to the public comments and its plans to post comment resolution on the Internet.

Specific Comments

1. Multiple Barriers

We understand that the staff's approach in the proposed regulation for demonstrating multiple barriers is to require that DOE demonstrate reliance on both natural and engineered barriers and that the repository system not depend unduly on any single barrier. We understand that the staff plans to require use of hypothetical calculations wherein barriers are assumed to perform to a lesser degree than anticipated, as a way of gaining insights into the contributions of barriers to overall repository performance. In addition, the staff may require in the rule that the results of the barrier underperformance analyses be compared to a numerical dose failure criterion. The staff also plans to provide more detailed guidance on acceptable methods to demonstrate compliance of multiple barriers in the Yucca Mountain Review Plan (YMRP).

The ACNW has closely followed the development of draft 10 CFR Part 63. In past advice, the Committee has endorsed the staff's general approach to address multiple barriers in the draft rule and has commended the staff for developing a regulation that captures the intent of risk-informed, performance-based (RIPB) regulation. We also advised the Commission that the performance of individual barriers should be quantified, and we recommended that the staff use a post-processor approach to decomposing overall repository performance assessments to quantitatively expose the contribution of individual barriers (References 2-6).

The Committee believes that the staff's proposal to calculate barrier underperformance is an acceptable approach for quantifying the contribution of individual barriers. However, we recommend that the staff not set a quantitative dose limit in the rule for comparison with the hypothetical assessments for performance of multiple barriers. In the spirit of a performance-based philosophy of regulation, the Committee would prefer that the measure of barrier performance always be in terms of its effect on overall repository performance. The ACNW recommends an approach (see enclosure) that involves comparison of risk curves showing calculated system performance with and without a specific functional barrier. Such an approach avoids comparison of the hypothetical results to a surrogate risk value or a subsystem requirement and, in our view, is more consistent with the staff's original performance-based strategy for draft 10 CFR Part 63 in SECY-97-300 (Reference 7).

We appreciate the competing demands placed on the staff to both specify a clear, numerical limit for evaluating compliance while at the same time develop a truly RIPB regulation that is less prescriptive. If the staff elects to use a surrogate risk value, as we understand is being proposed, we recommend incorporating the quantitative dose limits for the hypothetical calculations in the YMRP rather than in the rule itself.

2. Performance Confirmation

We understand that the NRC staff agrees with the public comments that some sections of the rule were too prescriptive and has modified the rule to allow DOE greater flexibility to develop a focused and effective performance confirmation plan. The Committee supports the staff's proposed approach to performance confirmation. We recommend that in its review of the DOE's performance confirmation plan, the staff encourage that DOE's monitoring scheme be designed in parallel with the repository design. Optimal placement of monitoring devices should not be precluded.

3. Design Basis Events

The staff is considering a number of clarifications in the proposed final rule, including eliminating the term "design basis event" and replacing it with the term "event sequence," to clarify that the probability of a design basis event is based on the entire event sequence.

The ACNW supports the staff's proposed clarifications, including elimination of the term "design basis event" in the proposed rule to avoid confusion and miscommunication. The Committee considers that the traditional concept of design basis is contrary to or at odds with an RIPB approach. The concept traditionally has been used to prescribe design requirements that are not necessarily linked to the performance measure of risk.

We recommend that the importance of event sequences in terms of their impact on the radiation dose to the critical group be the principal basis for allocating analysis and investigation resources to ensure the safety of the public and protection of the environment.

4. Human Intrusion

We understand that the staff is proposing to revise the consequence limit for evaluating human intrusion to an annual dose limit of 1000 mrem (10 mSv). This approach is consistent with the approach used in other NRC regulations for beyond-design-basis conditions. Other aspects of the hypothetical intruder analyses remain unchanged, that is, a single borehole is drilled at 100 years, a single canister is breached, and release of radionuclides to the groundwater pathway is evaluated. The staff believes that its proposed approach provides insights into the repository's resilience to human intrusion, yet avoids the undue conservatism that would result by comparing the results of the hypothetical intruder analyses to the overall performance objective of 25 mrem (0.25 mSv) per year.

The Committee supports the Academies' recommendation (Reference 8) pertaining to human intrusion to analyze different human intrusion scenarios for purposes of testing the robustness of the repository, not for calculating its probability of occurrence. We believe that the best approach to the human intrusion issue is to test the "hardness" of the repository and avoid debating arbitrary frequencies (for example, a 100-year drilling scenario frequency) for an event over which there is very little control.

The Committee recommends that the staff avoid the use of surrogate risk values, such as 1000 mrem (10 mSv) per year, in the regulation. We recommend that the staff compare the results of the hypothetical intruder analyses to the results of the performance assessment analyses. If the staff decides that a license application could be evaluated more easily by a comparison of the results of the hypothetical calculation with a higher dose limit, we recommend that this approach be incorporated into the guidance rather than the rule itself.

5. Waste Retrievability

The staff notes in its response to public comment that NRC will conduct an extensive and careful review of DOE's retrieval plans as part of any construction authorization review. However, DOE will not need to build full-scale prototypes at the time of construction authorization but will have to demonstrate technical feasibility of its retrieval plans using sophisticated computer simulations before receiving a license to receive and emplace waste. NRC notes that DOE needs to design and build the repository in such a way that the retrieval option is not rendered impractical or impossible. The staff proposes no changes to this section of the rule.

The Committee considers that waste retrieval does not present an insurmountable technological challenge. The Committee supports the staff's proposed approach to require DOE to plan for but not to demonstrate that the waste package is retrievable before issuing a license to construct the repository.

6. Transportation

In its response to public comments, the staff makes clear that transportation of HLW is not addressed in 10 CFR Part 63 because NRC and the Department of Transportation (DOT) have existing regulations that address transportation of HLW to a repository. The staff also offers some clarification of NRC's and DOT's role and governing regulations for the transportation of HLW in general and specifically to the proposed repository.

The ACNW has previously recommended that DOE be required to perform a comprehensive assessment of transportation risk to be evaluated by the NRC as part of the overall licensing decision regarding Yucca Mountain (Reference 9). A large experience base of the radiological risks associated with transportation already exists. The ACNW supports the staff's decision not to address transportation in 10 CFR Part 63. We continue to emphasize the need for clarification and improved management of the overall transportation issue because no single agency has the authority to take a total systems approach to address this public policy issue.

Sincerely,

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B. John Garrick
Chairman

Enclosure:
B. John Garrick, Draft Technical Note, "On the Quantification of Defense in Depth," January 13, 2000.

<u>References</u>:

1. Memorandum (undated) from Donald A. Cool, Office of Nuclear Material Safety and Safeguards, to addressees, requesting review and concurrence on a Final Rulemaking Establishing 10 CFR Part 63 - Disposal of High-Level Radioactive Waste in a Proposed Geological Repository at Yucca Mountain, Nevada (Predecisional).

2. ACNW letter dated October 31, 1997, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Recommendations Regarding the Implementation of the Defense-In-Depth Concept in the Revised 10 CFR Part 60.
3. ACNW letter dated October 31, 1997, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Application of Probabilistic Risk Assessment Methods to Performance Assessment in the NRC High-Level Waste Program.
4. ACNW letter dated March 6, 1998, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: ACNW's Support for the NRC Staff's Approach to Assessing the Performance of Multiple Barriers.
5. ACNW letter dated July 29, 1998, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Comments on NRC's Total System Sensitivity Studies for the Proposed High-Level Radioactive Waste Repository at Yucca Mountain, Nevada.
6. ACNW letter dated September 3, 1998, from B. John Garrick, Chairman, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Advisory Committee on Nuclear Waste Comments on NRC's Draft 10 CFR Part 63 and Revision 0 of the Total System Performance Assessment Issue Resolution Status Report.
7. SECY-97-300, dated December 24, 1997, Subject: "Proposed Strategy for Development of Regulations Governing Disposal of High-level Radioactive Wastes in a Proposed Repository at Yucca Mountain, Nevada"
8. National Research Council, "Technical Bases for Yucca Mountain Standards," 1995.
9. ACNW letter dated January 20, 2000, from B. John Garrick, ACNW, Chairman, to Richard A. Meserve, Chairman, NRC, Subject: Comments on the Draft Environmental Impact Statement for Yucca Mountain.

Draft Technical Note

ON THE QUANTIFICATION OF DEFENSE IN DEPTH

B. John Garrick
January 13, 2000

PURPOSE

To propose a conceptual framework for quantifying the "defense-in-depth" aspects of the various levels of protection, provided in nuclear plants and nuclear waste repositories, against the release of radiation to the public and the environment.

GENERAL FEATURES OF THE APPROACH

The question is how can we best use probabilistic risk (performance) assessment (PRA and PPA) results to quantify and make visible the performance of the various "defense-in-depth" systems designed to provide multiple "levels of protection" against the release of radiation. Part of the answer lies in the way that the results are presented.

The key to the proposed approach, therefore, is a presentation format that clearly displays 1) the role that the individual safety systems play in providing protection against the release of radiation to the environment and 2) the effect of the individual systems acting in concert. This format allows for important risk and performance comparisons to be made at both the functional and system levels of a nuclear plant or a nuclear repository. It helps us make the important judgments of whether we are getting our money's worth from these multiple levels of defense, and whether we need more or less.

The approach utilizes the results of PRA and PPA. The scope of the PRAs and PPAs must include quantifications of information and modeling uncertainties, in the parameters used to measure risk or safety performance, and explicit identification of the supporting evidence on which these quantifications are based. The PRAs and PPAs must be structured in such a way as to reveal the process of assembling the results into the final measures of risk or performance, and to reveal the contributions, to these final measures, of the various levels of protection.

SPECIFIC FEATURES OF THE APPROACH

The answer to "how can we best use PRA and PPA results to quantify --- defense-in-depth ---" is believed effectively addressed using a two-dimensional structuring of risk and performance results. The structuring can be done in stages or phases in the spirit of a top-down approach. To illustrate the process at the functional level for reactors, consider Figure 1 with respect to the PRA of a boiling water reactor.

The rows of Figure 1 represent classes of initiating events at the functional level that can lead to core damage. In the first column (column 1) we plot probability curves showing our state of knowledge about the frequencies of the initiating events in the "probability of frequency" format. Columns 2─5 now represent the various safety functions that may respond to a particular class of initiating events. Column 6 contains the core damage frequencies for each class of initiating events. The sum of the Column 6 results represents the total core damage frequency, as illustrated in the last row.

The question is what entries should go in the boxes under the safety functions? The answer is to show the entries that best expose the defense-in-depth contributions of the safety functions. There are many possibilities. One possibility is to include three entries in each grid box, as shown in Figure 2.

As discussed further below, Entry 1 (Figure 2a) could be a probability curve indicating the unavailability frequency per demand of the safety function, given the particular class of initiating events. Entry 2 (Figure 2b) could be the core damage frequency, given the unavailability of the safety function, and Entry 3 (Figure 2c) could compare this result with the total core damage frequency of the last row. Doing this for each of the grid boxes would provide a clear perspective of the amount of protection provided by each of the functions. Different combinations of safety function availability and unavailability could be presented through the use of additional columns for making performance comparisons. Such analyses and comparisons provide a process for quantifying the role of various levels of protection, and hence, a quantification of contribution to defense-in-depth provided by different levels of protection.

TURNING UP THE MICROSCOPE

Now, the functional level shown in Figure 1 is too high a level to reveal performance characteristics of specific systems and barriers. To do that we need to turn up the microscope. Consider the grid box formed by the intersection of "Loss of Coolant" and "Inventory Control" of Figure 1. Suppose we detail that grid box into Figure 3.

Figure 3 divides the "Loss of Coolant" class of initiating events into six initiating event categories. It divides the "Inventory Control Systems" into eight more clearly defined protection systems. This level of detail is usually sufficient to provide quantitative engineering information on the levels of protection against exposing the public and the environment to radiation. The entries in the grid boxes can be the same as Figure 1 or modified as appropriate. In particular, Figure 2a indicates the unavailability of the safety system on demand, given the applicable initiating event. It reveals the reliability of the system under the conditions that the system is called on to operate and is the input used in the calculation of the core damage frequency for each specific category of initiating events. Figure 2b is the core damage frequency as a result of a particular category of initiating events, given the unavailability of the safety system (e.g., if that safety system were not present).

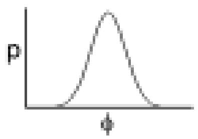
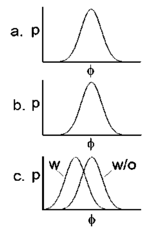
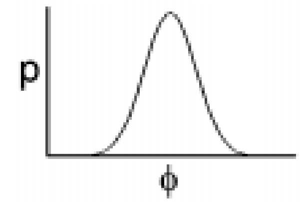
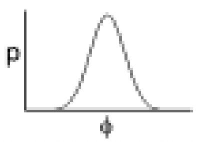
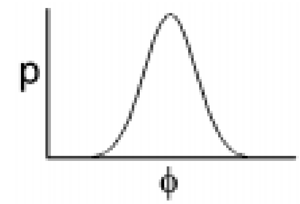
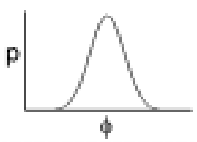
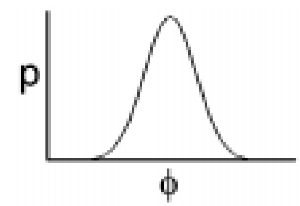
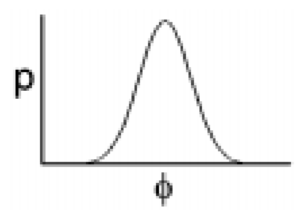
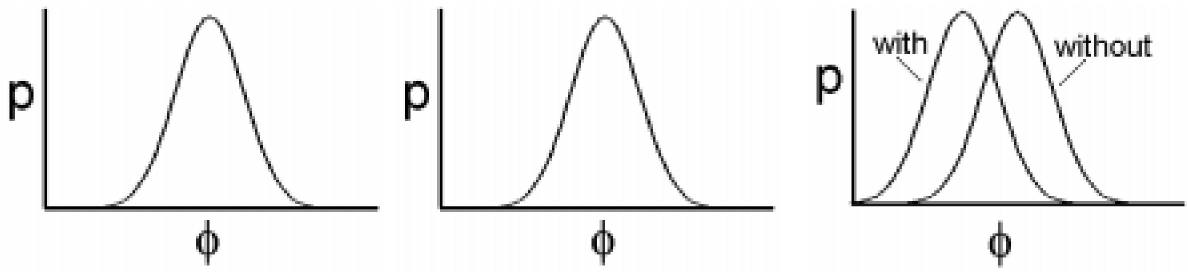
(1) Classes of Initiating Events	Safety Functions				(6) Core Damage Frequency
	(2) Reactivity Control	(3) Inventory Control	(4) Heat Removal	(5) Radionuclide Content	
Loss of Coolant 		Etc.			
Transients 					
External Events 					
Total Core Damage Frequency					=Σ(CDFs of Col. 6)

FIGURE 1. BWR SAFETY FUNCTIONS



System Unavailability Frequency per Demand
(a)

Core Damage Frequency (System Unavailable)
(b)

Total Core Damage Frequency (With and Without Safety System)
(c)

FIGURE 2. SYSTEM PERFORMANCE INDICATORS

Figure 2c is a key result in the quantification of the defense-in-depth of safety system protection. It is the total core damage frequency with and without the specific safety system being analyzed. It is important to note that Figure 2c is a different CDF than the one on which Figure 2b is based. The Figure 2b CDFs are those of Column 6. The Figure 2c CDF is the probabilistic sum of the Column 6 CDFs.

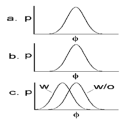
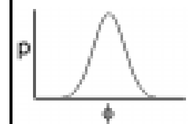
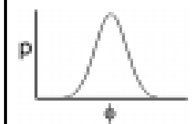
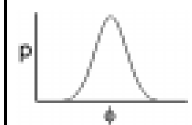
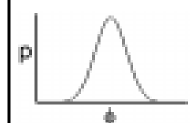
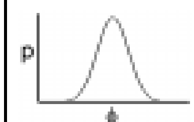
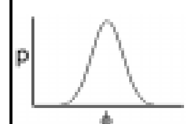
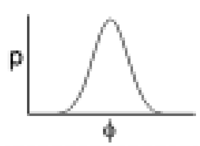
(Loss of Coolant Accident (LOCA) Indicators)	Safety Systems							Reactor Coolant System	Core Damage Frequencies (CDFs)
	Vessel-Level Makeup								
	Feedwater and Condensate	High-Pressure Core Spray	Reactor Core Isolation Cooling	Automatic Depressur-ization	Residual Heat Removal	Low-Pressure Core Spray	Fire Water		
Excessive LOCA		Etc.							
Large LOCA									
Small LOCA									
Breaks Outside Containment									
Interfacing System LOCA									
Other LOCAs									
CDF Due to LOCA Initiating Events									=Σ(CDFs of IE Categories)

FIGURE 3. BWR SAFETY SYSTEMS

APPLICATION TO NUCLEAR WASTE REPOSITORIES

Defense-in-depth of a nuclear waste repository takes the form of passive barriers whose performance must be analyzed over tens and hundreds of thousands of years. A two-dimensional display similar to the above can be constructed to exhibit the contributions of the levels of defense associated with a repository design. The functional barriers protecting the biosphere from radioactive contamination are, as shown in Figure 4, the spatial and flow control of water, the waste package containment, and the control of the mobilization and transport of radionuclides. The effectiveness of these barriers must be analyzed under a set of "geological scenarios" representing the possible climatological and geological events that might occur over tens and hundreds of thousands of years of the repository history. In Figure 4 these scenarios are represented in rows 2, 3, and 4. Row 1 represents the "base case" or "expected" scenario.

The point of Figure 4 is to display the contribution of the individual functional barriers to preventing the release of radioactivity to the biosphere. For this purpose we take, as the repository performance measure, the peak annual release to the biosphere, measured in curies.

In Figure 4, the rightmost column shows our state of knowledge about the peak annual release to the biosphere under the four geological scenarios. In the individual boxes of Figure 4 we display a pair of curves of the type shown in Figure 5. The curves show the contributions of the individual protective barriers by showing how the peak annual release would increase if that barrier were not present.

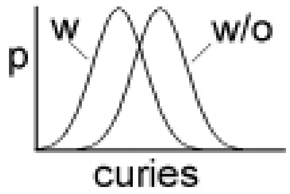
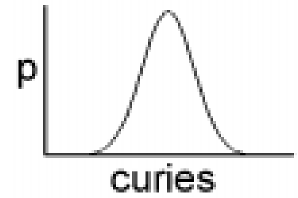
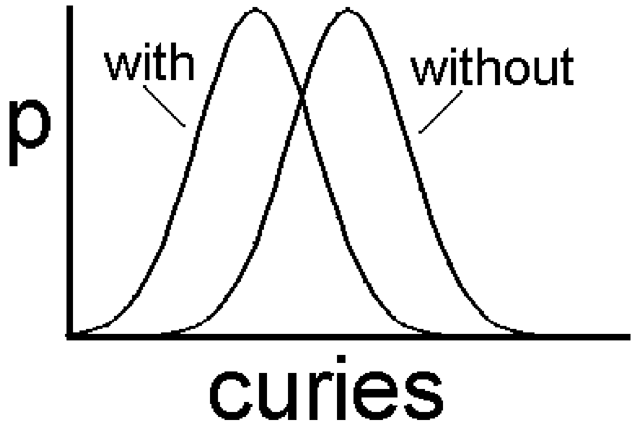
Initiating Conditions	Protective Barrier Functions			Peak Annual Release to the Biosphere (Curies)
	Water Flow and Spatial Control	Waste Package Containment	Radionuclide Mobility Control	
Current Climate		Etc.		
Geological Events				
Wet Climate				
Increased Geological Activity				

FIGURE 4. REPOSITORY PROTECTIVE BARRIER PERFORMANCE



Peak Annual Release
(With and Without Barrier)

FIGURE 5. PERFORMANCE COMPARISON

In Figure 6 we "turn up the microscope" on Figure 4 and recognize that the "barriers" shown in Figure 4 are actually composed of specific protective barriers. For example, the barrier "Water Flow and Spatial Control" of Figure 4 is now recognized as being composed of "Surface Runoff," which refers to a drainage system on the surface above the repository. Such a drainage system would divert the surface rainfall so as to prevent it from infiltrating into the ground above the repository. The column labeled "Water Diversion (Geotechnical)" refers to engineering the subsurface geology such as by the design of a Richards barrier. The column labeled "Water Diversion (Engineered Systems)" represents those engineered systems in the near field explicitly introduced to keep water from reaching the waste package. The rest of the columns are pretty much self-explanatory.

The individual boxes of Figure 6 show the impact of the protective barriers on repository performance by displaying what the peak annual release would be if that protective barrier were not present.

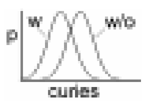
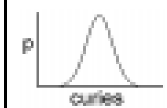
<table>
<tr><th rowspan="3">Initiating Conditions</th><th colspan="7">Protective Barriers</th><th rowspan="3">Peak Annual Release to the Biosphere (Curies)</th></tr>
<tr><th colspan="3">Water Flow and Spatial Control Systems</th><th colspan="2">Waste Package Containment</th><th colspan="2">Radionuclide Mobility Control Systems</th></tr>
<tr><th>Surface Runoff</th><th>Water Diversion (Geological)</th><th>Water Diversion (Engineered Systems)</th><th>Corrosion Resistance</th><th>Fuel Cladding</th><th>Chemical Activities</th><th>Solubility, Retardation, Dilution</th></tr>
<tr><td>Current Climate</td><td></td><td>Etc.</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Geological Events</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wet Climate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Increased Geological Events</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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FIGURE 6. REPOSITORY PROTECTIVE BARRIER PERFORMANCE