DRAFT FOR COMMENT

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DRAFT SAFETY ANALYSIS
LONG-TERM HAZARD OF MILLSTONE UNIT 1'S MISSING SPENT FUEL RODS POTENTIALLY DISPOSED AT THE BARNWELL COMMERCIAL LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY

In November 2000, Dominion Nuclear Connecticut, Inc., the licensee for Millstone Unit 1, informed the U.S. Nuclear Regulatory Commission (NRC) that the location of two spent fuel rods could not be determined. The licensee formed an investigative team, which completed its investigation in October 2001.[1] A follow-up NRC inspection reviewed the findings of the investigation and agrees with the results.[2] These results indicated there is a chance that the rods may have been unintentionally disposed at either the Hanford, Washington, or Barnwell, South Carolina, commercial low-level radioactive waste disposal facility. The most likely explanation was that the rods were inadvertently shipped to Barnwell in 1988, as part of a shipment of Class C low-level radioactive waste. For the purposes of this safety analysis, the staff is assuming that the fuel rods were disposed at the Barnwell facility, to assess the potential for health and safety risks. This safety analysis does not address the jurisdictional issues raised by the potential disposal of spent fuel at a low-level waste disposal facility.

There are both short- and long-term considerations for reviewing the health and safety impacts of the rods potentially being at Barnwell. These include the type and amount of radioactivity present, the current location and disposition of the suspected shipments, potential future ground-water release, and risk potential inadvertent intruders. Dominion Nuclear Connecticut, Inc., provided an safety analysis[3] of the risks from the missing fuel on October 5, 2001. A safety analysis[4] was provided on May 15, 2002, which responded to a NRC request for additional information.[5] After assessing the short- and long-term considerations, it has been determined that the presence of the two fuel rods at Barnwell does not constitute a present or future risk to the public health and safety nor to the environment.

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[1] "Millstone Unit 1 - Issuance of Final Report Pertaining to Unaccounted for Spent Fuel Rods," October 5, 2001, ML012850396.

[2] "Special Inspection 05000245/20011013, Dominion Nuclear Connecticut, Inc., Millstone Power Station Unit 1, Waterford, Connecticut," February 27, 2002, ML020580132.

[3] "Safety Analysis of Millstone Fuel Rods Potentially Disposed in Either the Barnwell, South Carolina or Hanford, Washington Commercial LLRW Disposal Sites," Dr. Michael T. Ryan, C.H.P., October 5, 2001, ML020320392.

[4] "Response to a Request for Additional Information Regarding Safety Analysis of Millstone Unit No. 1 Missing Fuel Rods," May 15, 2002, ML021500428.

[5] "Safety Analysis of Millstone Unit 1 Missing Fuel Rods," February 14, 2002, ML020450361.

The two fuel rods presently contain an estimated 17 terabecquerel (TBq) [460 curies (Ci)], with the predominate, by activity, radionuclides, shown in Table 1. Most of this activity is in fission products with half-lives of equal to or less than 30 years (see Table 1). If the rods were inadvertently exhumed today, the external exposure rates of the fuel rods might result in grave danger [approximately 10 gray per hour (1000 rad/h)] to the intruder. Most of this threat is caused by the fission products, which are important for analyzing short-term hazards. Radiological decay will reduce the activities significantly before the long-term hazards, such as releases to ground-water or inadvertent intrusion, would likely could occur. As shown in the table, the total activity will drop from 17 TBq (460 Ci) to about 0.4 TBq (10.8 Ci) in approximately 500 years.

TABLE 1. ACTIVITY PRESENT BY PREDOMINATE RADIONUCLIDES AND TOTAL ACTIVITY IN TWO FUEL RODS

Present Inventory		Year 500 Inventory	
Radionuclide (Half-life)	Activity [TBq (Ci)]	Radionuclide (Half-Life)	Activity [TBq (Ci)]
Cesium-137 (30 yrs)	4.0 (109)	Zirconium-93 (1.5 million yrs)	0.16 (4.4)
Barium-137M (2.6 min)	3.8 (103)	Americium-241 (430 yrs)	0.13 (3.5)
Strontium-90 (29 yrs)	3.1 (85)	Plutonium-239 (24,000 yrs)	0.06 (1.7)
Yttrium-90 (2.7 days)	3.1 (85)	Plutonium-240 (6500 yrs)	0.04 (1.1)
Plutonium-241 (14 yrs)	2.1 (57)		
Americium-241 (430 yrs)	0.3 (7.4)		
Total Fission Products	14.5 (392)	Total Fission Products	0.17 (4.5)
Total Actinides	2.5 (68)	Total Actinides	0.23 (6.3)
Total Activity	17 (460)	Total Activity	0.40 (10.8)

The current risk to human health from the missing fuel rods, if they were disposed at Barnwell, is negligible. The potential shipments that may have contained the rods have been disposed in Class C trenches that have engineered barriers. Any retrieval option would need to evaluate the potential risks to workers, which could be significant. However, with the rods presenting no current risk to workers or the public, and very little risk to future generations, retrieval would likely result in more actual dose being delivered to workers, than the potential dose future generations could receive, if the rods were not retrieved.

Another potential hazard is the long-term release of radionuclides from the fuel rods to the ground-water. The disposal site currently has a total inventory in excess of 18,500 TBq (5 million Ci). The ceramic and activated steel waste forms of the spent fuel rods would limit the release rate, as compared with the release rate expected from the larger volume and activity present in all the Class A wastes at the site. In addition, the fuel rods do not introduce any new radionuclides to the site, although for some specific radionuclides, the fuel rods may be a significant fraction of the total activity disposed at Barnwell. These radionuclides, isotopes of plutonium, americium, and curium, however, are not major contributors to long-term release through the groundwater pathway, as these elements are not very mobile. Overall, the incremental releases that could result from the fuel rods would be insignificant compared to potential releases to ground-water from the rest of the site, and therefore would not constitute any significant increase in the risk to the future generations or the environment.

Inadvertent Intruder Scenarios

The inadvertent intruder scenarios assume that at some point after closure of the facility, the site is forgotten and is accidentally used by others for a residence. In the development of 10 CFR Part 61, NRC assumed that the intrusion would occur either 100 or 500 years after closure of the facility. The scenarios analyze the various opportunities that could occur to contact the buried waste. These include drilling a well, building a home, or growing a garden in exposed waste. The licensee's May 15, 2002, safety analysis provides adequate summaries of each of the scenarios, along with references to the original sources of the scenarios.

The small compact nature of the fuel rods reduces the probability of the waste being inadvertently exhumed. The inadvertent intruder scenarios were developed to analyze the overall risk from many waste disposals, not a single specific shipment. Coupling the small compact nature of the fuel rods with the current size of the waste facility results in odds that if a well were to be dug anywhere on the site, with equal probabilities, there would be less than 1 in a million chance of the well intercepting the location where the fuel rods might be buried. Although the odds of a basement being placed over the waste are higher because of the basement's greater footprint, the basement would not intrude on the waste, because of the depth of the burials, as discussed below.

As stated previously, NRC, in developing Part 61, analyzed inadvertent intruder scenarios at 100 years and 500 years post-closure. Because of considerations on the degree of decomposition, and degree to which an intruder may not recognize the material as waste, Classes A and B waste disposal cells are analyzed at 100 years. In the case of Class C disposal cells, which is where the suspect casks would be buried, intruder barriers (e.g., bentonite covers, reinforced concrete, other engineered cover designs, and the waste package) would need to be fairly decomposed, resemble ordinary strata, and/or not provide resistence to the drilling rig, and, therefore, it is generally assumed that the intruder barriers would preclude any intrusion into the waste, before 500 years. Even after 500 years, the waste form of the fuel rods also reduces the probability of the inadvertent intruder scenarios (except for discovery). Most inadvertent intruder scenarios have as a fundamental assumption that the waste is sufficiently decomposed to resemble ordinary soil. Realistically, the fuel rods and disposal casks will not likely decompose to resemble ordinary soil in 500 years.

Another consideration is the depth of the disposals. The waste is buried approximately 6.1-7.6 m (20-25 ft) below existing disposal-cell final grade at Barnwell. For the building construction and agricultural intruder scenarios, the assumption is that the cover material and waste within 3 m (9.8 ft) of the surface would be exhumed and spread around the final structure. The basement, which is rare in that area of South Carolina, would not intersect the buried waste, because of its depth. Therefore, no further analysis of the building, discovery, or agricultural scenarios, which require waste to be dispersed over the surface, are necessary.

The only remaining intruder scenario to consider is the well-drilling scenario, which intersects the fuel rods. In this scenario, an intruder is drilling a ground-water well for domestic use. The scenario assumes that a two-person drilling crew uses a hydraulic drilling rig, or another rig appropriate for the region. In the methodology used for development of Part 61, the crew digs to a depth of 61 m (200 ft).

The scenario assumes that the drill does not encounter resistance from the intruder barriers present over Barnwell's Class C trenches, and that some waste comes to the surface, mixed with water and clean soil, ending up in a drilling mud pit. The driller helper is assumed to be standing adjacent to the mud pit and could receive direct gamma radiation from the waste. At the end of the operation, the mud pit would be covered with soil.

The conceptual model for this exposure scenario conservatively ignores any shielding factor for any water or covering mud in the drill pit during the time the helper is exposed to external radiation. The helper is assumed to stand next to the pit for 6 hours. The total exposure would be less than 0.002 mSv (0.2 mrem). This is far below the 5-mSv/y (500-mrem/y) dose value that was used in assessing intruder doses for Part 61.

If a well were drilled through the facility and then used for drinking water or irrigation, the same conclusions for the passive ground-water release, discussed above, would apply. Although the infiltration rate would increase, the ceramic and activated steel would reduce the release rates of radionuclides. Releases to ground-water from other waste similarly affected, or even the Class A trenches that are not affected, would likely be greater.

The conclusion, from these analyses, is that the overall risk from the fuel rods, if they are at Barnwell, is minimal to both the present workers and future generations of the public. Low-probability inadvertent intruder scenario analyses resulted in potential doses not only well below the 5-mSv/y (500-mrem/y) dose value used for inadvertent intruder analyses but also below the regular Part 61's 0.25-mSv/y (25-mrem/y) public dose limit for releases of radioactive material (10 CFR 61.41). Based on the very low risk that the fuel rods pose, if they are at Barnwell, retrieval of the rods would not be justified by arguments concerning public health and safety.