PR 73
(75FR62695)

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DOCKETED
USNRC

April 11, 2011 (9:55 am)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

April 8, 2011

ATTN: Rulemakings and Adjudications Staff
Secretary
US Nuclear Regulatory Commission
Washington, DC 20555-0001
Rulemaking.Comments@nrc.gov

Docket ID: NRC-2009-0163, Proposed Rule, Physical Protection of Irradiated Reactor Fuel in Transit, 10 CFR Part 73

The State of Nevada Agency for Nuclear Projects respectfully submits the attached comments and supporting documents in response to the proposed rule published in the Federal Register on October 13, 2010 (75 FR 62695-62716).

We appreciate the extension of the comment period to April 11, 2011.

Sincerely,

JCStt

Joseph C. Strolin
Acting Executive Director

JCS/RH/js
cc Marta Adams, Deputy Attorney General
Affected Units of Local Government and Tribes
Western Interstate Energy Board HLW Committee

Template = SECY-067

DS 10

State of Nevada Comments On The
U.S. Nuclear Regulatory Commission Proposed Rule:
Physical Protection of Irradiated Reactor Fuel in Transit10 CFR Part 73

April 8, 2011

General Comments

The State of Nevada strongly endorses the proposed rule.

The proposed rule is necessary because there have been significant changes in the threat environment, which affect both current and future spent nuclear fuel shipments. The proposed rule reflects realistic assessments of changes in the threat environment since the terrorist attacks of September 11, 2001.

The proposed rule is necessary because of the greater understanding, achieved since 1999, of the potentially disastrous consequences of successful acts of terrorism or sabotage against spent nuclear fuel shipments. Analyses prepared for the State of Nevada demonstrate that such attacks could result in hundreds to thousands of latent cancer fatalities, and tens of billions to hundreds of billions of dollars in economic losses.

The provisions of the proposed rule, coupled with other NRC actions since 2001, and other changes in NRC regulations since 2007, would adopt most all of the regulatory changes requested by Nevada in its 1999 petition for rulemaking (PRM-73-10). Three of Nevada's requests which were rejected by the Commission - changes to the design basis threat, a comprehensive assessment of attack consequences, and mandatory use of dedicated train - have been largely satisfied by other developments.

Nevada remains concerned, however, about the exemption of DOE spent nuclear fuel and high-level radioactive shipments to a geologic repository or storage facility constructed under the Nuclear Waste Policy Act (NWPA). In the future, this could create an incongruous situation in which the NRC physical protection regulations would apply to the expected 20 or so licensee shipments per year, while the projected 250-500 or more DOE shipments per year to NWPA facilities would not be regulated by NRC.

Comments on Part III, Discussion, Item C: What is requested by the State of Nevada in its petition for rulemaking (PRM-73-10)? (75 FR 62697-62699)

"The NRC invites comments on its disposition of items 2 through 7 of PRM-73-10 as part of its consideration of this proposed rule."

<u>General Comments on NRC Consideration of the Nevada Petition for Rulemaking</u>

In June 1999, the State of Nevada Attorney General filed a petition for rulemaking with the NRC. Nevada requested that NRC amend the current safeguards regulations in order to better deter, prevent, and mitigate the consequences of any attempted radiological sabotage against shipments of spent nuclear fuel (SNF) and high-level radioactive waste (HLW). Nevada also requested that NRC conduct a comprehensive assessment of the consequences of terrorist attacks that have the capability of radiological sabotage, including attacks against transportation infrastructure used during nuclear waste shipments, attacks involving capture of nuclear waste shipments and use of high energy explosives against a cask or casks, and direct attacks upon a nuclear waste shipping cask or casks using antitank missiles or other military weapons.

In the petition, Nevada documented the vulnerability of shipping casks to high-energy explosive devices. Nevada also submitted evidence that shipments to a national repository would be dramatically different from past shipments in the United States and that these differences would create greater opportunities for terrorist attacks and sabotage. Between 1964 and 1998, Nevada was traversed by approximately 321 truck shipments and 16 rail shipments of civilian SNF to and from nuclear reactor sites, research facilities, and interim storage facilities. Studies prepared by Nevada contractors, DOE, and the NRC indicated the potential for 20,000 to100,000 truck and rail shipment of SNF and HLW, over 30 to 40 years, to the proposed repository at Yucca Mountain.

The NRC docketed the petition (PRM-73-10), published it in the *Federal Register* on September 13, 1999 (64 FR 49410), and accepted public comments through February 2000. The Western Governor's Association endorsed Nevada's petition on behalf of 18 western States. Five other states (LA, MI, OK, VA, and WV) and three Nevada counties (Nye, Clark and Eureka) endorsed all or part of the petition. The Nuclear Energy Institute supported comprehensive assessment of "credible threats of sabotage and terrorism on spent fuel in transit." DOE, the Department of the Navy Nuclear Propulsion Program, the Association of American Railroads, and five other organizations and individuals, opposed both Nevada's request for rulemaking and for a comprehensive assessment.

<u>Comments on NRC Disposition of PRM-73-10, Item 2</u>

While NRC "considers that the existing definition already encompasses actions of the type described by" the petition, the NRC proposed rule has responded by adding the following language to the definition of "Radiological sabotage" in the supporting guidance document (NUREG/CR-0561, Rev.2, p.3): "For purposes of SNF fuel transportation, the definition of radiological sabotage also considers deliberate acts that cause or are intended to cause economic damage or social disruption, regardless of the extent to which public health and safety are endangered by exposure to radiation." The NRC clarification of the existing definition, and the additional language in NUREG/CR-0561, Rev. 2, fully address Nevada's concerns regarding Item 2.

<u>Comments on NRC Disposition of PRM-73-10, Item 3</u>

The NRC proposed rule has adopted an approach to routing different than that requested by Nevada, but Nevada believes that the NRC approach will achieve the primary objective sought by Nevada, "to minimize movement of spent nuclear fuel through heavily populated areas." Nevada's concerns about the security of rail shipments through urban areas are now also addressed by regulations enacted in 2008 by the U.S. Department of Homeland Security's Transportation Security Administration (TSA) (49 CFR Parts 1520 and 1580, 73 FR 72130) and the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) (49 CFR Parts 172, 179, and 209, 73 FR 72182). The NRC proposed rule requires licensees to consider both the DOT and NRC routing requirements before submitting route approval requests to NRC.

NRC rejected Nevada's request that the current route selection security criteria for shipments through non-urban areas be made mandatory. However, Nevada believes that the new State preplanning involvement requirements in the NRC proposed rule, combined with the requirements for State involvement under the new TSA and PHMSA rail security regulations, would allow affected States to address unique local conditions important for physical protection of shipments along rural routes.

Comments on NRC Disposition of PRM-73-10, Item 4

The NRC proposed rule has adopted Nevada's request that armed escorts be required along the entire road shipment route by eliminating the differential requirement based on population. The proposed rule states: "The differentiation of security requirements based upon population causes potential areas of vulnerability along the shipment route for theft, diversion, or radiological sabotage." The proposed rule fully addresses Nevada's concerns.

Comments on NRC Disposition of PRM-73-10, Item 5

The NRC proposed rule has adopted Nevada's request that armed escorts be required along the entire rail shipment route by eliminating the differential requirement based on population. "The proposed rule would require that the same security requirements for heavily populated areas apply along the entire route for road and rail shipments, and at any U.S. ports where vessels carrying spent shipments are scheduled to stop." The proposed rule fully addresses Nevada's concerns.

Comments on NRC Disposition of PRM-73-10, Item 6

The NRC proposed rule has adopted the substance of Nevada's request by requiring additional planning and scheduling requirements similar to those for shipments of formula quantities of special nuclear materials. The proposed rules require licensee preplanning and coordination with corridor States to ensure minimal shipment delays, arrange state law enforcement escort arrangements, and coordinate safe haven locations. The proposed rules also require development of normal and contingency procedures (including responses to actual, attempted, or suspicious activities), and training all shipment personnel to be prepared to prevent theft, diversion, or radiological sabotage. The proposed rule fully addresses Nevada's concerns.

Comments on NRC Disposition of PRM-73-10, Item 7

The NRC proposed rule rejected Nevada's request that 10 CFR 73.37(d) be amended to require that all rail shipments of spent nuclear fuel be made in dedicated trains. NRC believes the issue is resolved by requiring the same new strengthened security requirements for all rail shipments, whether shipped in dedicated trains or general freight service. "Thus, this item is not addressed as part of the proposed rulemaking."

From Nevada's standpoint, developments since 1999 have eliminated the need for an NRC requirement for mandatory use of dedicated trains. In 2004, the Nuclear Energy Institute issued a statement supporting use of dedicated trains for utility rail shipments of spent fuel. In 2005, DOE adopted a policy of using dedicated trains for "usual shipments." The DOE 2008 SEIS states that it is DOE policy "to use dedicated trains for most shipments" to a repository. (SEIS, p.6-3) The TSA and PHMSA rail security regulations adopted in 2008 virtually require use of dedicated trains for spent fuel shipments. As of 2010, all rail shipments of SNF, except DOE shipments of naval reactor spent fuel, are expected to use dedicated trains exclusively, and rail carriers may decide to use dedicated trains for naval SNF shipments. In addition, Nevada believes that the new strengthened security requirements included in the NRC proposed rule will make general freight rail shipments of spent nuclear fuel impractical.

Comments on NRC Denial of PRM-73-10, Item 1

On December 7, 2009, the NRC published in the Federal Register a notice entitled "State of Nevada; Denial of Portions of Petition for Rulemaking, Consideration of the Remaining Portions in the Rulemaking Process" (74 FR 64012). This notice denied the Nevada request identified by NRC as "Item 1" in the proposed rule.

In the 1999 petition, Nevada requested that the Commission reexamine the design basis threat used to design safeguards systems to protect shipments of SNF against acts of radiological sabotage. Nevada specifically requested the Commission clarify the meaning of "hand-carried equipment" regarding certain man-portable explosive devices (such as the U.S. Army M3A1 shaped charge and the TOW 2 antitank missile) which might be used against SNF shipments. Nevada further requested the Commission, as part of a comprehensive reassessment of the consequences of terrorist attacks, consider larger weapons and the use of military attack vehicles or military aircraft, because of the number and nature of military installations in Nevada and along the transportation corridors to Nevada.

NRC stated that it is denied Nevada's request because specific details of adversary's capabilities are contained in classified or safeguarded documents, which "must be withheld from public disclosure and made available on a need to know basis to those who are cleared for access." Further, the NRC made reference to its Final Rule Amending 10 CFR 73.1 Design Basis Threat issued in 2007 (72 FR 12705), and asserted that Nevada's request "would not be consistent with the Commission's recent revision to Section 73.1."

Nevada supports the protection of classified and safeguarded information. However, the man-portable weapons specified in the 1999 petition have over the past decade been evaluated in publically available, unclassified consequence assessments prepared for DOE and for the State of Nevada. The debate over credible attack scenarios has shifted to other issues, such as the use of multiple weapons. The NRC Construction Authorization Boards considering the DOE Yucca Mountain License Application accepted six NEPA contentions filed by Nevada challenging the adequacy of the DOE SEIS transportation sabotage evaluations. (Order, 05-11-2009) The

Nevada contentions and supporting documents evaluate attack scenarios using the same kind of large military demolition devices and man-portable antitank weapons systems described in Item 1 of PRM-73-10.

Nevada also believes that the request in Item 1 is not inconsistent with the NRC amended design basis threat. In fact, the amended design basis threat adopted by NRC in 2007 partially addresses Nevada's 1999 request, acknowledging the need to consider the "potential for attacks on spent fuel shipments by multiple coordinated teams of a large number of individuals." (72 FR 12712) The amended definition of "radiological sabotage" NRC adopted in 2007 includes expanded weapons capabilities and adversary attributes (72 FR 12723-12724) that partially accommodate Nevada's 1999 request.

Comments on NRC Denial of PRM-73-10, Item 8

The NRC denial notice published on December 7, 2009 (74 FR 64012) also denied Nevada's request that NRC conduct a comprehensive assessment of the consequences of terrorist attacks.

Nevada requested a comprehensive reexamination of terrorism and sabotage consequences not only to determine the adequacy of the current physical protection regulations, but also to assist DOE and the affected stakeholders in the preparation of a legally sufficient environmental impact statement as part of the NRC licensing process for a geologic repository or an interim storage facility. Nevada suggested specific guidelines for assessing the impacts of an event resulting in release of radioactive materials, including: immediate and long-term implications for public health; environmental impacts, broadly defined; standard socioeconomic impacts, including cleanup and disposal costs and opportunity costs to affected individuals and business; and so-called special socioeconomic impacts, including individual and collective psychological trauma, and economic losses resulting from public perceptions of risk and stigma effects.

Nevada further requested that the Commission's consequence assessment evaluate the advantages and disadvantages of increasing the escort requirements for SNF shipments to seven armed escorts, the same level of protection as for shipments of strategic special nuclear materials.

NRC denied Nevada's request "because it does not involve (i.e., contain) a request to amend, create, or revise the NRC's existing regulations... Instead of requesting changes to the NRC's regulations (as it has specified for other topics elsewhere in its petition) the Petitioner has requested the NRC complete a comprehensive assessment. A comprehensive assessment is not a change to the language of the NRC's regulations." NRC noted that "relevant studies (which accomplish the objectives of the Petitioner) were performed at the request of the Commission following the September 11, 2001, terrorist attacks." The NRC denial makes no claim that Nevada's request for a comprehensive assessment would create a conflict with the protection of classified or Safeguards Information.

The NRC denial ignores Nevada's request that a comprehensive assessment should evaluate the advantages and disadvantage of a major change in the existing regulations, a very substantial increase in the number of armed escorts, from one or two armed escorts per shipment, to seven armed escorts per shipment

At the time of the petition, no comprehensive assessment of sabotage consequences had been performed since 1984. Since 1999, assessments based on publically available, unclassified information have been prepared for DOE and for the State of Nevada. The NRC denial notice makes no reference to these assessments. The denial notice also makes no reference to the May 2009 Order issued by the NRC Construction Authorization Boards considering the DOE Yucca Mountain License Application, which accepted six NEPA contentions filed by Nevada challenging the adequacy of DOE's evaluation of transportation sabotage.

DOE acknowledged the vulnerability of shipping casks to terrorism and sabotage in the 2002 Final EIS for Yucca Mountain, and in the 2008 Supplemental EIS for Yucca Mountain, which was submitted to the NRC as part of the repository license application. The SEIS estimated that a single-weapon attack, penetrating one wall of the cask, could result in a 32,000-47,000 person-rem population dose and 19-28 latent cancer fatalities in an urban area, and cleanup costs similar to a severe transportation accident, in the range of $300,000 to $10 billion. A DOE-sponsored study estimated that a single-weapon attack that fully penetrated the cask, creating an exit hole, could increase the amount of radioactive material released as an aerosol by about 10 times, compared to the one-hole penetration. A Nevada-sponsored study estimated that a multiple weapon attack, which created an exit hole, would increase the release of radioactive cesium by 100 times or more. The resulting population dose was estimated to be 55-202 times greater than the SEIS estimate; the dose to the maximally exposed individual was estimated to be 555-1,615 times greater; and cleanup costs were estimated to be hundreds of billions of dollars(2008$) in an urban area. (See Attachment A)

Comments on Part III, Discussion Item P: How are the NRC and DOE requirements similar and how are they different?

The discussion under this item substantially understates the differences between spent fuel shipments regulated by NRC and self-regulated DOE shipments, particularly large-scale shipping campaigns to a geologic repository or a centralized storage facility constructed under the Nuclear Waste Policy Act (NWPA).

Shipments of SNF and HLW to the formerly proposed Yucca Mountain repository would not have been regulated by NRC, except for use of NRC-certified casks and shipment notification to states, as specifically required by the NWPA. As former NRC Chairman Richard Meserve explained in 2002, "If DOE takes custody of the spent fuel at the licensee's site, DOE regulations would control the actual spent fuel shipment. Under such circumstances, the NRC's primary role in transportation of spent fuel to a repository would be certification of the packages used for transport. ... However, if NRC licensees are responsible for shipping the spent fuel not only must the transport container be certified by the NRC, but also the shipment must comply with NRC regulations for the physical security of spent fuel in transit (10 CFR Part 73). NRC licensees are subject to inspection for compliance with the NRC's transportation safety and security regulations. The NRC also issues Quality Assurance (QA) program approvals for radioactive material packages that apply to the design, fabrication, use and maintenance of these packages. Activities conducted under an NRC QA program are also subject to NRC inspection." [R.A. Meserve, Responses to Questions from Senator Durbin, Letter dated March 22, 2002, NRC-Durbin-ML021060662.pdf, May 10, 2002.]

A major outstanding issue for potential corridor States and other stakeholders is the exemption of DOE shipments of spent nuclear fuel and high-level radioactive waste to a geologic repository or storage facility constructed under the NWPA. NWPA shipments would continue to be exempt under the proposed rule. In the future, this could create an incongruous situation in which the NRC physical protection regulations would apply to the expected 20 licensee shipments per year, while the projected 250-500 DOE shipments per year to NWPA facilities would not be regulated by NRC.

Both DOE and NRC have long sought to assure stakeholders that DOE self-regulation would meet or exceed NRC physical protection requirements. But as the proposed rule notes, DOE may exempt itself from NRC standards "if there is a determination that national security or another critical interest requires different action." Stakeholder concerns have been fueled by the DOE position that NWPA shipments would be in compliance as long as their physical protection requirements were "the equivalent" of 10 CFR 73.37. Stakeholders believe DOE self-regulation lacks a credible inspection and enforcement mechanism, and fails to ensure performance of the comprehensive system of critical security planning and operations tasks required under the proposed rule.

The NRC physical protection route approval process is a particularly important example of the difference between NRC regulation and DOE self-regulation. "Once a spent nuclear fuel shipment route request is received, the NRC reviews it closely. The NRC conducts a detailed review, considering route length and minimizing transit time, local law enforcement and emergency response contact information, adequacy of safe haven locations, and communications capability along the route." [75 FR 62699] NRC would also review the licensee's consideration of DOT routing requirements, and the licensee's interactions with the affected States. This is precisely the kind of comprehensive, independent regulatory guidance and oversight that DOE cannot provide for its own activities.

Comments on Part IV: Discussion of the Proposed Amendments by Section

Comment 1, A. Proposed Section 73.37(a) (1), 75 FR 62703

Nevada supports the proposed rule revisions regarding use of both metric and English units, and clarification that the term "irradiated reactor fuel" means "spent nuclear fuel."

Comment 2, B. Proposed Section 73.37(a) (1) (i), 75 FR 62703

Nevada supports the proposed rule revisions which remove the distinction for armed guard requirements between heavily populated areas and other areas through or across which a spent nuclear fuel shipment may pass. Nevada agrees with NRC that these revisions address items 4 and 5 of PRM-73-10.

Comment 3, C. Proposed Section 73.37(a) (2), 75 FR 62703

Nevada supports the proposed rule revisions regarding terminology, renumbering of paragraphs, and clarification that the licensee should delay, as well as impede, any attempted theft, diversion, or radiological sabotage of spent nuclear fuel shipments.

Comment 4, D. Proposed Section 73.37(b), 75 FR 62704

Nevada supports the proposed rule revisions regarding a step-by-step approach to development of a physical protection system.

Comment 5, E. Proposed Section 73.37(b) (1), 75 FR 62704

Nevada supports the proposed rule revisions which add a new section entitled "Preplan and Coordinate Spent Nuclear Fuel Shipments." Nevada specifically endorses the provisions intended to ensure that the armed guards are knowledgeable of the Federal and State statutes regarding the use of deadly force. Nevada specifically endorses the new accounting and control measures intended to ensure that only authorized individuals receive the shipment. Nevada specifically endorses the requirements for licensees to preplan and coordinate spent nuclear fuel shipments with States. Nevada supports the intended goal of the proposed amendments, to ensure that States have early and substantial involvement in the management of spent nuclear fuel shipments by participating in the initial stages of the planning, coordination, and implementation of the shipments. Nevada specifically endorses the proposal to expand the requirements for licensee preplanning and ordination with NRC, including: identification of locations for safe havens along highway routes; obtaining the NRC route approval prior to the 10 day advance notice; provision of specific information to NRC; and the new requirements for documentation of licensee preplanning and ordination activities.

Comment 6, F. Proposed Section 73.37(b) (2), 75 FR 62704

Nevada supports the proposed rule revisions regarding contact information for state governors and governors' designees, shipment date and time information, and new recordkeeping and shipment cancellation notification requirements.

Comment 7, G. Proposed Section 73.37(b) (3), 75 FR 62704

Nevada supports the proposed rule revisions which add a new subsection entitled "Transportation Physical Protection Program." Nevada specifically endorses use of the term "movement control center" and the proposed requirements for development and operation of movement control centers, including personnel training requirements, and revised requirements for periodic escort reporting, constant visual surveillance by at least one armed escort, and periodic reporting on shipment status.

Comment 8, H. Proposed Section 73.37(b) (4), 75 FR 62705

Nevada supports the proposed rule revisions regarding "Contingency and Response Procedures," including additional requirements regarding development of written procedures, personnel training, and recordkeeping.

Comment 9, I. Proposed Section 73.37(c), 75 FR 62705

Nevada supports the proposed rule revisions which eliminate the distinction between heavily populated areas and other areas along road shipment routes, regarding armed escort requirements, and the proposed new weapons requirements for armed escorts. Nevada endorses eliminating requirements for specific types of communications technology, in favor of specifying performance characteristics of the communications capabilities. Nevada also endorses the requirement for continuous and active monitoring of the shipment by a telemetric position monitoring system or an alternative tracking system.

Comment 10, J. Proposed Section 73.37(d), 75 FR 62705

Nevada supports the proposed rule revisions which eliminate the distinction between heavily populated areas and other areas along rail shipment routes, regarding armed escort requirements, and the proposed new weapons requirements for armed escorts. Nevada endorses eliminating requirements for specific types of communications technology, in favor of specifying performance characteristics of the communications capabilities. Nevada also endorses the requirement for continuous and active monitoring of the shipment by a telemetric position monitoring system or an alternative tracking system.

Comment 11, K. Proposed Section 73.37(e), 75 FR 62705

Nevada supports the proposed rule revisions which eliminate the distinction between heavily populated areas and other areas along sea shipment routes, regarding armed escort requirements along routes and at U.S. ports, and weapons requirements for armed escorts. Nevada endorses eliminating requirements for specific types of communications technology, in favor of specifying performance characteristics of the communications capabilities. Nevada also endorses the requirement for continuous and active monitoring of the shipment by a telemetric position monitoring system or an alternative tracking system.

Comment 12, L. Proposed Section 73.37(f), 75 FR 62705

Nevada supports the proposed new requirement for an immediate investigation if a shipment is lost or unaccounted for after the designated no-later-than arrival time, in order to facilitate the location and recovery of shipments that may have come under control of unauthorized persons.

Comment 13, M. Proposed Section 73.37(g), 75 FR 62705

Nevada supports the proposed new requirements regarding protection of safeguards information.

Comment 14, N. Proposed Section 73.38, 75 FR 62706

Nevada supports the proposed new requirements regarding personnel access authorization, and licensee responsibilities for establishing and maintaining an effective access authorization program. Nevada endorses the requirements for background investigation for individuals who would be granted unescorted access or access authorization relative to spent nuclear fuel in transit.

Comment 14, O. Proposed Section 73.72(a) (4), 75 FR 62707

Nevada supports the proposed new requirement that licensees notify NRC two hours before the commencement of the shipment, and notify NRC when the shipment arrives at its final destination.

Comment 15, P. Proposed Section 73.72(a) (5), 75 FR 62707

Nevada supports the provision clarifying notification for schedule changes of more than six hours.

Comment 16, Q. Proposed Section 73.72(b), 75 FR 62707

Nevada supports the proposed new requirements that licensees inform NRC of any spent nuclear fuel shipment on a public road, even those of short duration, to ensure that NRC is prepared to respond to any emergency or safeguards event. This provision is important at reactor sites that might ship spent fuel casks to off-site storage facilities, or utilize trucks for intermodal transfer of shipping casks to off-site rail or barge facilities.

ATTACHMENT A

Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container:

Updated Analysis
Revised Final Version

Prepared for the State of Nevada Agency for Nuclear Projects

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November 2008

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Consequences of a Successful Sabotage Attack on a Spent Nuclear Fuel Shipping Container

This report updates our previous report[1] of the potential consequences of a successful sabotage attack on a truck or rail cask containing spent nuclear fuel (SNF). Since carrying out our previous analysis, much has changed in the ensuing six years. In the most recent Department of Energy (DOE) Supplemental Environmental Impact Statement (SEIS)[2] for Yucca Mountain, DOE uses smaller capacity rail casks, the spent fuel that would be transported to the repository has a higher burn up (resulting in a larger radioactive inventory for each fuel assembly shipped), and the population density along shipping routes has been escalated to the year 2067 (50 years after the proposed repository opening). However, DOE continues to assume that a sabotage attack would utilize a single weapon, and DOE assumes smaller fractional radioactive releases in a successful sabotage event. In this report, a successful sabotage attack using explosive devices would completely perforate the cask, creating an exit hole for radioactive materials to escape. This greatly increases the potential releases and potential consequences.

To estimate the economic consequences of a sabotage attack on a truck or rail cask transporting spent nuclear fuel through an urban area, we first determine the amount of radioactive material being released, and then calculate the air and surface concentrations resulting from this release. Following a sabotage attack on a spent nuclear fuel cask, a plume of radioactive material is wafted and deposited downwind of the sabotage site. The release of radioactive material will impact people downwind who are outdoors, as well as people who are downwind and indoors, depending on the response time of emergency responders in reaction to the sabotage attack. Being that urban areas are heavily populated and often support a large tourist population, buildings such as offices, hotels, and casinos will be in the path of the dispersing radioactive material released from the sabotaged cask. These buildings can import radioactive materials inside of their facilities if they are unable to shut off their ventilation systems before the contamination plume has dispersed to their location. To simplify the calculations we follow the SEIS and assume a person remains outside for two hours following the event and for a full year thereafter. We do not assume a person ingests contaminated food or water.

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1 RWMA, 2002. Lamb, M. *et al.*, *Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: An Analysis of the Yucca Mountain EIS Treatment of Sabotage*, Radioactive Waste Management Associates, April 2002.

2 USDOE, 2008. *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F-S1, June 2008. The SEIS incorporates by reference the radiological impact analyses contained in the accompanying DOE Final EIS for the Nevada Rail Transportation Corridor (DOE/EIS-0250-F-S2) and the Final EIS for a Rail Alignment for the Construction and Operation of a Railroad in Nevada (DOE/EIS-0369), June 2008.

It would be difficult to calculate the downwind contaminated surface concentrations for every urban area in the United States because all cities vary in physical and atmospheric conditions. To obtain a population density representative of United States urban areas, the DOE SEIS[3] combines the population densities of the 20 most populated urban areas in the United States, based on the 2000 United States Census. Las Vegas, Nevada, is not considered one of the 20 most populated urban areas in the 2000 United States Census data, and therefore the SEIS included Las Vegas resident and tourist populations in the urban area population density. In its SEIS, DOE projects the urban population density to the year 2067, based on the assumption that the Yucca Mountain repository opens for operation in 2017 and remains in operation for 50 years. To project the urban population density to 2067, DOE used the Bureau of the Census population estimates for the years 2000 through 2030, and population estimates for 2026 through 2030 to extrapolate national urban population densities to the year 2067. In the state of Nevada, DOE used data from the state demographer and the computer model, REMI (Regional Economic Model, Inc.), to extrapolate population densities to the year 2067. The radioactive plumes we generate are superimposed on a map of the City of Las Vegas and its environs, since a successful attack in downtown Las Vegas may have the greatest impact of any of the cities in the United States.

Potential Spent Fuel Shipments through Las Vegas

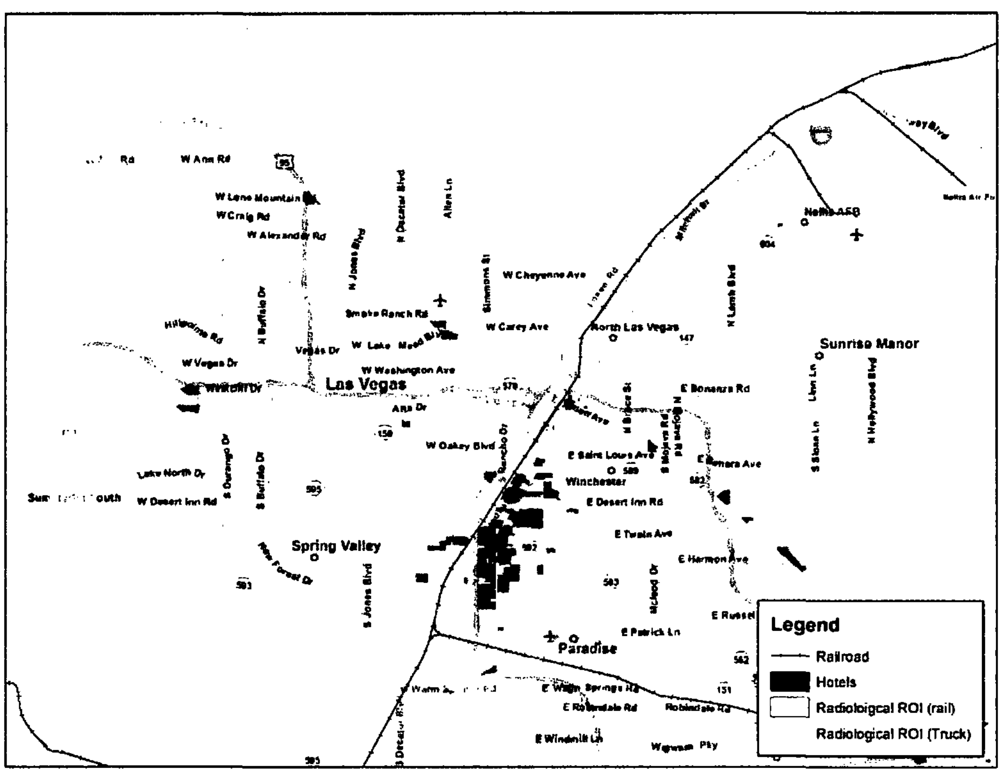
The SEIS provides information on the potential numbers of shipments to Yucca Mountain through Las Vegas, and the highway and rail routes that DOE would use for these shipments. The SEIS assumes about 8 percent of the rail shipments would travel through downtown Las Vegas on the Union Pacific mainline if the Caliente rail access option is developed. State of Nevada studies indicate that 40-80 percent of the rail shipments could use the Union Pacific Railroad (UPRR) through Las Vegas if the Caliente rail line is built, resulting in one or more rail shipments per week through downtown for 50 years. In addition to rail shipments, the SEIS assumes about 2,500 to 5,000 truck shipments to Yucca Mountain, about one or two shipments per week over 50 years, all of which would travel through the Las Vegas metropolitan area.

The potential impacts of these shipments on Las Vegas, for both routine transportation and accidents and incidents, can be evaluated in relation to the regions of influence for occupational and public health and safety. In the Rail Alignment EIS[4], DOE defines the region of influence (ROI) for radiological impacts of incident-free transportation as "the area 0.8 kilometer (0.5 mile) on either side of the centerline of the rail alignment." DOE defines the affected environment for public radiological impacts as: (1) residents within the region of influence, "including persons who live within 0.8 kilometer (0.5 mile) of either side of the centerline of the rail alignment;" and (2) individuals at locations "such as residences or businesses near the rail alignment." For radiological impacts of transportation accidents and

[3] USDOE, 2008, pp. 6-4 to 6-5.
[4] USDOE, 2008b, pp. 3-3 to 3-5.

sabotage, DOE defines the ROI as "the area 80 kilometers (50 miles) on either side of the centerline of the rail line."

Figure 1 below shows the potential DOE highway and rail routes through metropolitan Las Vegas and the routine (incident-free) radiological region of influence (ROI), one-half mile (800 meters), on each side of the routes. An analysis prepared for the State of Nevada, based on 2005 Bureau of Census estimates, concluded that about 95,000 residents currently live within one-half mile of the rail route, and about 113,000 residents currently live within one-half mile of the highway routes. There are also 34 hotels with 49,000 hotel rooms located within one-half mile of the rail route. The State of Nevada estimates that more than 1.8 million residents live within the 50 mile region of influence for accidents and sabotage, along potential truck and rail routes, in southern Nevada and adjacent areas of Arizona, California and Utah.[5]



[5] Halstead, RJ, *et al*, 2008. *State of Nevada Perspective on the U.S. Department of Energy Yucca Mountain Transportation Program,* Paper presented at Waste Management 2008, Phoenix, AZ, February 25, 2008. http://www.state.nv.us/nucwaste/news2008/pdf/wm2008perspective.pdf

Figure 1. Potential Rail and Highway Routes through Las Vegas and 0.5-Mile Radiological Region of Influence (ROI) for Incident-Free Transportation

Figure 2 below shows the DOE potential national highway and rail routes to Yucca Mountain and the radiological region of influence (ROI) for sabotage and accidents, 50 miles (80 kilometers), on each side of the routes. Nationally, about 218 million people lived with-in the 50-mile ROI for transportation sabotage and accidents in 2000, according to an analysis based on 2000 Census data prepared for the State of Nevada.[6]

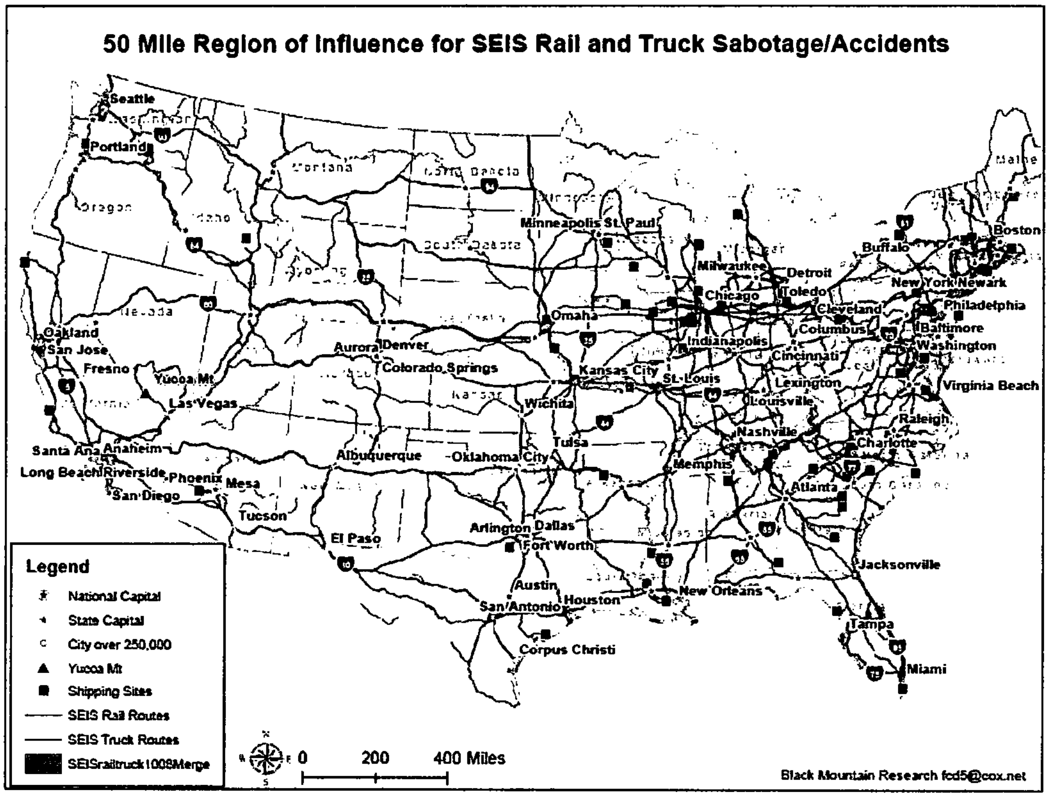


Figure 2. Potential National Rail and Highway Routes and 50-Mile Radiological Region of Influence (ROI) for Sabotage and Accidents

[6] Dilger, F, 2008. *50-Mile Region of Influence for Yucca Mountain Transportation Sabotage and Accidents,* Memorandum prepared for State of Nevada Agency for Nuclear Projects, October 21, 2008.

Truck and Rail Potential Sabotage Scenarios

The chosen scenario for a sabotage attack on a truck carrying spent nuclear fuel through Las Vegas incorporates an attack that successfully penetrates both walls of the fuel cask, as seen in Figure 3 below.[7] Similar to the SEIS, we assume the spent fuel burnup is 60GWD/MTU and is 10 years cooled. The truck cask contains four PWR fuel assemblies. As we discuss below, the total Cesium-137 released from the sabotaged truck cask is 1.76E+04 Ci. The truck sabotage attack site is assumed to be located on the near south side of Las Vegas at the intersection of I-15 and I-215, south and west of Las Vegas Boulevard ("The Strip"). Both highways and this intersection are identified in the SEIS as segments of the planned transportation routes to Yucca Mountain.

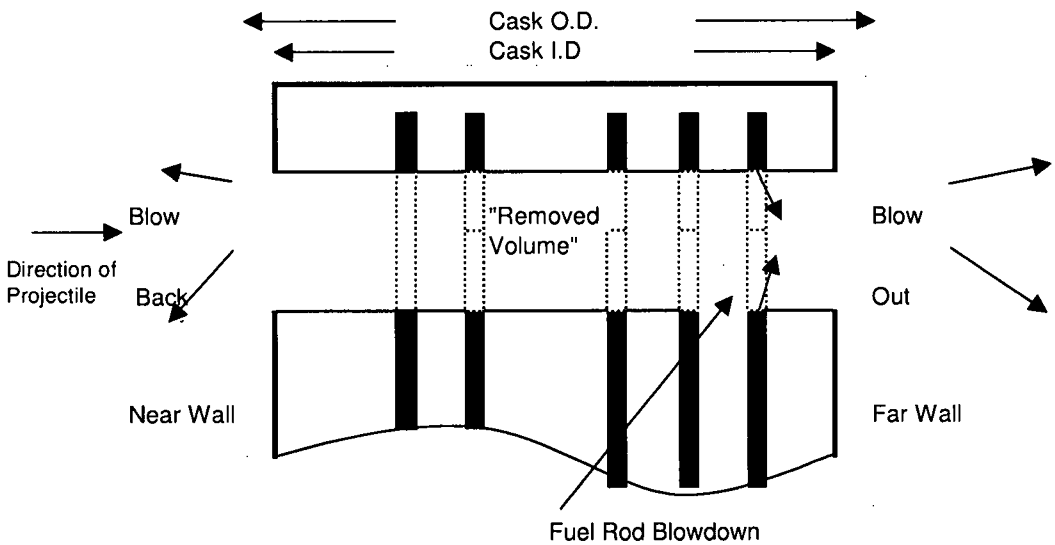


Figure 3. Simplified Diagram of Spent Fuel Cask and release pathways following Successful Terrorist Attack

The scenario for a sabotage attack on a rail cask transporting spent nuclear fuel through Las Vegas also incorporates an attack that successfully penetrates both walls of the fuel cask. The rail cask is the proposed TAD cask, containing 21 PWR fuel assemblies, as assumed in the SEIS. The rail casks actually used for shipments to the repository could be larger, with

[7] Collins, HE, 2003. *Recommendations for a Consequences Study of a Terrorist Attack Against SNF Shipments to Yucca Mountain*, Final Draft Report, Prepared for Nevada Agency for Nuclear Projects, April, 2003.

capacities of 24, 26, 28 or more PWR assemblies. The spent fuel burnup is assumed to be 60 GWD/MTU and the fuel has been cooled 10 years. In this scenario, the total Cesium-137 released from the sabotaged rail cask, as discussed below, is 4.35E+04 Ci. The rail sabotage attack site is assumed to be located on the Union Pacific Railroad line just north of Flamingo Road, and west of I-15 and Las Vegas Boulevard ("The Strip"). This rail line is identified in the SEIS as a segment of the planned transportation routes to Yucca Mountain.

Release Assumptions

The release from the rail cask is based on the following assumptions:

1. Assume attack on 21-PWR TAD, with internal arrangement based on NAC diagram (3-5-5-5-3), Fig. 4.

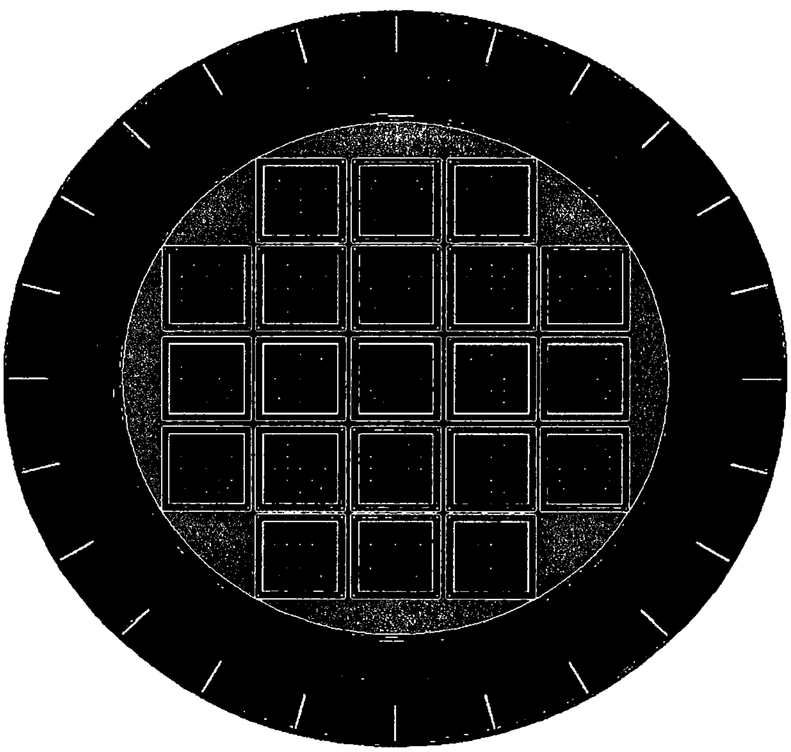


Figure 4. TAD Rail Cask[8]

2. Assume rail overpack design based on existing designs for NUHOMS, HOLTEC, and NAC rail casks.

[8] Pennington, CW, 2007. *From Observations to Lessons Learned: TAD Specification Development and Proof of Concept Design Effort.* NEI Dry Storage Information Forum, Clearwater Beach, FL, May 16, 2007.

2. Assume successful attack using at least two weapons comparable to the TOW-2 warhead or the M3A1 demolition charge, first weapon penetrates cask 80-90%, second weapon placed in entry hole of first weapon, results in full perforation (100% penetration) and an exit hole on the opposite side of cask. (A horizontal attack on the side of the cask was assumed. Another orientation would perhaps be more adverse).
3. Assume weapons penetrate 5 of the 21 PWR assemblies in the TAD.
4. Assume reference PWR assembly physical dimensions from Yucca Mountain FEIS[9] (8.27" x 8.27" x 145.67", for a volume of 9,962.8 cubic inches).
5. Assume a cylindrical core of SNF equal in diameter to the blast hole is pulverized and ejected from the cask.
6. Assume that the blast hole has an average diameter of 6", and the volume of pulverized SNF pellets ejected from the cask is about 2.3 % of the total volume of the 5 PWR assemblies penetrated by the blasts or 5.48×10^{-3} of the total cask inventory[alternately, if the hole diameter is 4 inches, the volume ejected would be about 1.0 %; if the hole diameter is 2.5 inches (Army FM 5-250 rates the M3A1 as penetrating at least 20 inches of armor plate, with an average hole diameter of 2.5 inches) , then the volume ejected would be about 0.4 %] For the TAD cask, we make the same assumption as the SEIS, that all the Cs and I in the swept mass is volatilized and is in respirable size. In addition, the Cs in the gap between the cladding and the fuel pellet, 10% of the Cs inventory in the five fuel assemblies is released. We further assume that all this Cs, 2.9% of the TAD cask inventory of Cs, is released outside the cask. We realize that this is not the assumption made by Luna[10], but the conditions for the TAD cask and the Sandia experiment are different. The Sandia and GAR experiments[11] differ from real life conditions in that rail casks and inner canisters are pressurized. Within tens of seconds, the internal cask pressure should allow all internal aerosols to be vacated from the cask. We also accept Luna's assumption that 2% of the swept mass is aerosolized, so 1.096×10^{-4} of the particulate cask inventory is released as an aerosol. The deposition velocity of the aerosol is assumed to be 1 cm/sec. For the inventory that is released and is not aerosolized, 98% of the released particulates, the deposition velocity is assumed to be 10 cm/sec; these heavier particles fall closer to the cask. Cs is not released as a non-aerosolized particle.
7. Assume the cask is carrying the SEIS reference PWR SNF (60 GWDt/MTHM, 4.0 % initial enrichment, 10-years cooled, per page 6-9)
8. Assume the radionuclide inventories provided in SEIS Table G-15, page G-28 (for example, Cs-137, 71,600 curies/assembly) to estimate the release.
9. For the truck cask, 2 of 4 of the PWR assemblies have a swept volume of 2.3%. With a similar reasoning for the TAD cask, we determine that 6.15E-2 of the truck cask inventory of I and Cs are released as an aerosol, and 2.3E-4 of the truck inventory of particulates are

[9] USDOE, 2002. p. A-25.
[10] Luna, RE, 2006. *Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack.* WM 2006 Conference, February 26-March 2, 2006.
[11] GRS, 1994. Pretzsch, G and F Lange, 1994. *Experimental Determination of the Release of UO2 from a Transport Container for Spent Fuel Elements after Shaped Charge Bombardment*, Gessellshaft fur Anlagenund Reaktorsicherheit, Report GRS A-2157, May 1994.

released as an aerosol. For the non-respirable portion of particulates, 1.13E-2 of the cask inventory is released, with a deposition velocity 10 cm/sec. None of the Cs inventory is released as a nonrespirable particulate.

We contrast our assumptions regarding Cs release with those of DOE in Table 1 below.

Table 1. Cesium Release Assumptions

Size Particle	Release Time	SEIS No Exit Hole	RWMA Exit Hole
Respirable	Immediate	1 fuel assembly (fa) broken, all Cs in swept mass respirable (gap + matrix); range of release heights	Cs in 6" diameter swept mass of fa respirable (gap + matrix), released[a]; height 1.5m truck; 2.5 m rail
	Blowdown	Cask pressurized from breached fuel assembly; no Cs released from unbroken section of fa	Cs in gap of breached fuel assemblies released; 10% of Cs in gap
Non-Respirable	Immediate	No Cs released	No Cs released
	Blowdown	No Cs released	No Cs released

Notes: a. 5 of 21 fuel assemblies in TAD cask breached; 2 of 4 in truck cask breached

In Table 2 below, we compare the inventory, release fractions and total Cs-137 released in the SEIS and in this report. We also compare these releases with those in more severe accidents, Categories 5 and 6. Several aspects of the total Cs-137 releases should be noted:

1. In our calculation, the total Cs release from a rail cask is greater than from a truck cask. This is because we assume, in a two-hole model, that Cs that was assumed to be deposited on other surfaces within the cask in the Luna model, is released from the exit hole. It is also true that the entire rail cask is assumed to be pressurized; contrary to the actual physical situation, Luna[12] does not have the cask pressurized.
2. As our calculations below show, a sabotage event with an exit hole releases over 100 times as much cesium as a 1-hole sabotage event.
3. As seen below, the sabotage event releases 10 times as much cesium as the most severe rail accident, category 6.

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[12] Luna, 2006.

Table 2. A Comparison of Cesium-137 Releases

Source	Mode	Inventory	Release Fraction	Total Cs-137 Release	Comments
Sabotage					
SEIS	Rail	1.86E+06*	7.15E-06	1.33E+01	26 fuel assemblies, all Cs respirable
	Truck	2.86E+05	5.15E-04	1.47E+02	4 fuel assemblies, 60GWD/MTU, 10 yrs cooled
RWMA	TAD, Rail	1.50E+06	2.90E-02	4.35E+04	2-hole, 21 fuel assemblies, 60 GWD/MTU, 10 yrs cooled
	Truck, alt 4	2.86E+05	6.15E-02	1.76E+04	2-hole, 4 fuel assemblies, 60 GWD/MTU, 10 years cooled
Accident					
YMFEIS	Rail, Cat 5	1.58E+06	2.00E-04	3.16E+02	
	Rail, Cat 6	1.58E+06	2.00E-03	3.16E+03	
RWMA	Rail, Cat 5	1.58E+06	6.60E-03	1.04E+04	
	Rail, Cat 6	1.58E+06	6.60E-02	1.04E+05	

* All inventory and total Cs-137 quantities presented as curies of Cs-137.

Downwind Contaminated Surface Concentrations

The computer programs RISKIND[13] and Hotspot[14] were used to calculate the downwind contaminated surface concentrations that would result from potential sabotage attacks on a truck and rail cask transporting spent nuclear fuel through Las Vegas. As input parameters to the RISKIND and Hotspot programs, we used the average wind speed and direction of Las Vegas, 4.47 m/sec from the southwest, and the Pasquill Stability category D to represent neutral atmospheric conditions. Release heights of 1.5m[15] and 2.5m[16] were used for the truck and rail scenarios, respectively, assuming that the missile used in the sabotage attack hits the middle of both the truck and rail casks. Similar to the SEIS, we assume a short term exposure during passage of the radioactive cloud of two hours. We also assume that the contaminated areas are not decontaminated for one year, representing the dose one would be exposed to through direct gamma radiation from groundshine. To maximize the population exposure, we assume no indoor shielding, the assumption made by DOE.

[13] "RISKIND, Version 2.0." Argonne National Laboratory. SY Chen and BM Biwer, bmbiwer@anl.gov.
[14] "Hotspot, Version 2.06." Lawrence Livermore National Laboratory., https://www-gs.llnl.ov/hotspot/index.htm. Steve Hofmann, contact.
[15] RWMA, 2002.
[16] Adkins, et al, 2006. *Spent Fuel Transportation Package Response to the Baltimore Tunnel Fire Scenario.* NUREG/CR-688

Chapter 5 of the SAND96-0957 document[17] outlines the approach used to designate surface concentration clean up categories, and the RADTRAN 5 economic model couples these clean up categories with their appropriate remediation cost per square kilometer of contaminated surface. The SAND96-0957 document outlines areas considered to be "lightly contaminated" as those areas ranging in surface concentrations of 0.2-0.4 $\mu Ci/m^2$. Remediation actions associated with these levels of contamination include non-destructive decontamination activities such as washing and scrubbing, removing topsoil, as well as other "surface" decontamination activities. Areas considered to be "moderately contaminated" are those areas exhibiting surface contamination levels of 0.4-2.0 $\mu Ci/m^2$. Remediation actions associated with moderately contaminated surfaces include destructive decontamination, such as replacement of roofing, flooring, furniture, and all landscaping. Areas contaminated beyond the level of 2.0 $\mu Ci/m^2$ are considered to be "heavily contaminated." Remediation of surfaces that are heavily contaminated is thought to be impractical, so the costs associated with heavily contaminated surface clean up are a result of condemnation, acquisition, demolition, disposal, and restoration of property.

Downwind contaminated surface concentrations were calculated over the distance of 0.05 to 80.0 km from both the truck and rail sabotage attack sites using the RISKIND computer program. Figures 5 and 6 plot the downwind surface contamination isopleths for both the truck and rail sabotage scenarios in terms of lightly, moderately, and heavily contaminated surface concentrations. Figures 5a and 6a display surface contamination isopleths out to 80 km, for truck and rail sabotage events, respectively; Figures 5b and 6b display the close-in isopleths, out to 10 km from the potential sabotage event. As seen, major areas of Las Vegas, including The Strip, would be impacted by a sabotage event. As seen in Figures 5a and 6a, the surface contamination isopleths are not complete at a distance of 80 km downwind from the sabotage attack site, due to the fact that the parameters of the RISKIND computer program do not allow one to obtain surface concentrations for areas that extend past 80 km downwind of a sabotage site. Due to this limitation, we used the computer program Hotspot to calculate the surface contaminations beyond the scope of 80 km downwind from each sabotage site. Hotspot allows its users to calculate surface concentrations up to a maximum of 200 km downwind of an accident site.

The resulting outdoor Cs-137 downwind surface concentrations of the truck and rail cask sabotage attacks are listed in Tables 3 and 4, respectively. The contaminated surface areas were calculated in both the RISKIND and Hotspot computer programs. The areas calculated by RISKIND only account for contaminated areas that fall within a distance of 80 km downwind from the sabotage attack sites, therefore they do not account for the total area that is contaminated by the Cs-137 released from a sabotaged truck or rail cask. Hotspot was then used to calculate the area of the contaminated surfaces that fall within 200 km

[17] SAND96-0957. Chanin, D.I. and Murfin, W.B. *Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents.* May 1996. 6, p.5.15

downwind of the sabotaged cask. The completed isopleth representing heavily contaminated areas (those containing surface concentrations greater than 2.0 $\mu Ci/m^2$) does not extend past 200 km downwind of both the truck and rail sabotage sites, and Hotspot was able to accurately calculate the total area of heavily contaminated surfaces. The moderately and lightly contaminated isopleths dispersed from both the truck and rail sabotage sites are not complete by 200 km downwind of the sabotage site, and the limitations inherent of the Hotspot computer program would not allow us to calculate those total areas.

Table 3. Downwind Cs-137 Surface Concentrations: Truck Sabotage Attack.

	Contaminated Surface Area (km^2)	
Contamination Category	**RISKIND**	**HotSpot**
Heavily Contaminated	537.6	682.0
Moderately Contaminated	207.8*	not calculated
Lightly Contaminated	158.6*	not calculated

* The isopleths for moderate and light contamination extend further than 80 km, the contaminated surface areas of moderate and light contamination are much greater than those listed.

Table 4. Downwind Cs-137 Surface Concentrations : Rail Sabotage Attack.

	Contaminated Surface Area (km^2)	
Contamination Category	**RISKIND**	**HotSpot**
Heavily Contaminated	591.2	1000.0
Moderately Contaminated	344.3*	not calculated
Lightly Contaminated	N/A	Not calculated

* The isopleth for moderate contamination extends further than 80km, the contaminated surface areas of moderate contamination is greater than that listed.

Economic Consequences

The RADTRAN 5 economic model provides the clean up costs per square km associated with lightly, moderately, and heavily contaminated areas in 1995 dollar values. These values, which hold for a transportation accident or sabotage, have been converted to 2008 dollar values through a Consumer Price Index Ratio obtained from the Federal Reserve Bank of Minneapolis. The RADTRAN 5 cost estimates for the remediation of a mixed-use urban area are given in Table 5. We apply these cost estimates to the contaminated areas listed in Tables 3 and 4. It is important to note that the cleanup costs in Table 5 are based on a population density of 1344 persons/km^2, whereas the projected population density for an urban area in year 2067 is 4 times greater, according to the SEIS.

Table 5. Cost Estimates Obtained from RADTRAN 5 Economic Model.

Contamination Category	Surface Concentration Range (µCi/m^2)	Cost/km^2, 1995 dollars	Cost/km^2, 2008 dollars
Lightly Contaminated	0.2-0.4	$128,000,000	$181,000,000
Moderately Contaminated	0.4-2.0	$183,000,000	$259,000,000
Heavily Contaminated	>2.0	$395,000,000	$558,000,000

Tables 6 and 7 display the contaminated areas and the economic consequences of a sabotage attack on a truck and rail car transporting spent nuclear fuel through Las Vegas in terms of lightly, moderately, and heavily contaminated areas. It is important to note that the calculated clean up costs listed in Tables 6 and 7 cover the total cost of clean up for those areas categorized as heavily contaminated (calculated by Hotspot), but these tables do not cover the total cost of clean up for those areas categorized as moderately and lightly contaminated due to the limitations of the RISKIND and Hotspot computer programs. As seen in Figures 5a and 6a, if we were to complete the isopleths for moderately and lightly contaminated areas, the contamination plumes would extend much further out than 80 km and the cost of clean up for the whole contaminated area would be much greater than the costs presented in Tables 6 and 7.

Table 6. Cs-137 Clean Up Costs: Truck Sabotage Attack (w/ Exit Hole) in Las Vegas.

Contamination Category	Total Contaminated Surface Area (km^2)	Maximum Distance of Contamination Plume (km)	Total Cost 2008 Dollars
Heavy	682.0	146	$380,863,759,036.15
Moderate	207.8*	80*	$53,756,122,621.37
Light	158.6*	80*	$28,701,679,107.26
Total	**1048.4 ***		**$463,321,560,764.78**

*The isopleths for moderate and light contamination extend further than 80 km, the total moderately and lightly contaminated surface areas are greater than listed, and the total contaminated surface area is >>1048.4 km^2.

Table 7. Clean Up Costs: Rail Sabotage Attack (w/Exit Hole) in Las Vegas.

Contamination Category	Total Contaminated Surface Area (km^2)	Maximum Distance of Contamination Plume (km)	Total Cost, 2008 Dollars
Heavy	1000.0	200	$558,451,259,583.79
Moderate	344.3*	80*	$89,077,096,945.24
Light	N/A	N/A	
Total	**1344.3***		**$647,528,356,529.03**

* The isopleth for moderate contamination extends further than 80 km, the total moderately contaminated area is greater than listed, and the total contaminated surface area is >>1344.3 km^2.

Comparison to Previously Calculated Clean Up Costs

RWMA's previous report[18] of the potential economic consequences of a successful sabotage attack on a truck or rail cask transporting spent nuclear fuel calculated clean up costs through both the RADTRAN 4 and RADTRAN 5 economic models. Table 8 lists the estimated clean up costs resulting from a successful sabotage attack on both a truck and rail cask carrying spent nuclear fuel, calculated by both RADTRAN 4 and RADTRAN 5. The values in Table 8 have been translated from 2000 dollar values listed in our previous report to 2008 dollar values through a Consumer Price Index Ratio obtained from the Federal Reserve Bank of Minneapolis. All cost values listed in Table 8 are based on maximum Cs-137 release fractions stated in the Yucca Mountain FEIS[19] document. It should be noted that the values listed in Table 8 account for a sabotage attack that incorporates the penetration of only one cask wall. The addition of an exit hole due to the total penetration of a missile through both cask walls would increase the amount of Cs-137 released, therefore increasing the cost of clean up. Both the RADTRAN 4 and RADTRAN 5 economic models were originally used for a comparison of the two estimates due to several differences between the inherent input parameters of both economic models. These differences are discussed below.

Table 8. RWMA Previously Calculated Cs-137 Clean Up Costs.

Economic Model	Truck	Rail
RADTRAN 4	$22,272,431,174.87	$3,478,503,295.85
RADTRAN 5	$45,808,635,129.90	$7,007,056,998.84

RADTRAN 4 and RADTRAN 5 are economic models that were developed by Sandia National Laboratories and can be used to estimate economic consequences of a potential

[18] RWMA, 2002.
[19] USDOE, 2002.

accident, such as a sabotage attack on a truck or rail cask transporting spent nuclear fuel. The RADTRAN 4 economic model estimates clean up costs based on the population density of the area surrounding the sabotage attack and the time, in days, it takes to evacuate the contaminated area. RADTRAN 4 also assumes that once individuals have been evacuated from the contaminated area, they will be allowed to return after only ten days past the incident, as long as ground contamination levels are less than 40 times the EPA's Protective Action Guide's[20] clean up criterion of 0.2 $\mu Ci/m^2$. This assumption will greatly underestimate the actual clean up cost of a sabotage attack because it does not account for the cost of relocating evacuated individuals for a period longer than 10 days. Our previous report calculated four different clean up cost estimates for the maximum Cs-137 release fractions stated in the YM FEIS. These four cost estimates accounted for population densities of both 5404 or 6905 persons/km^2, and an evacuation time of either 1 or 7 days. The estimated clean up costs listed under RADTRAN 4 in Table 8 represent the greatest of the 4 economic costs calculated for both the train and rail cask sabotage attack scenarios. The RADTRAN 4 estimated cost values for both truck and rail in Table 8 are derived from a surrounding population density of 6905 persons/km^2 and an evacuation time of 7 days.

Chapter 5 of the SAND96-0957 document[21] outlines the approach used to designate surface concentration clean up categories, and the RADTRAN 5 economic model couples these clean up categories with their appropriate remediation cost per square kilometer of contaminated surface. The SAND96-0957 document outlines areas considered to be lightly, moderately, and heavily contaminated based on a range of decontamination factors that would be adequate for ground contamination clean up. A decontamination factor is a measurement used to evaluate the effectiveness of the radioactive contamination treatment. A decontamination factor can be measured as DF = 100/percent of contamination remaining after treatment. According to the EPA's Protective Action Guides, all radioactively contaminated areas should be decontaminated to a level below 0.2 $\mu Ci/m^2$.

The SAND96-0957 document categorizes areas considered to be lightly contaminated as those areas where a decontamination factor of 2 would be sufficient for remediation. Areas ranging in surface concentrations 0.2-0.4 $\mu Ci/m^2$ would be considered lightly contaminated. Remediation actions associated with these levels of contamination include non-destructive decontamination activities such as washing and scrubbing, removing topsoil, as well as other "surface" decontamination activities. Areas considered to be moderately contaminated are those areas where a decontamination factor between 2 and 10 would be sufficient for remediation. Areas exhibiting surface contamination levels of 0.4-2.0 $\mu Ci/m^2$ would be considered moderately contaminated. Remediation actions associated with moderately contaminated surfaces include destructive decontamination, such as replacement of roofing, flooring, furniture, and all landscaping. Areas considered to be heavily contaminated must have a decontamination factor greater than 10, and these areas are contaminated beyond the

[20] SAND96-0957.
[21] *Ibid.*

level of 2.0 $\mu Ci/m^2$. According to Sandia it is impractical to remediate surfaces that are heavily contaminated, so the costs associated with heavily contaminated surface clean up are associated with condemnation, acquisition, demolition, disposal, and restoration of property.

The RADTRAN 5 economic model is different from RADTRAN 4 in that it assumes a population density of 1344 persons/km^2, and calculates clean up cost estimates as a function of meteorological stability. RADTRAN 5 accounts for all Pasquill Stability Classes (A-F) and their associated probability of occurrence. The total clean up cost presented by the RADTRAN 5 economic model is the averaged total cost of clean up under all of the Pasquill Stability Classes. The clean up costs for both a truck and rail sabotage attack calculated by RADTRAN 5 are twice the costs calculated by the RADTRAN 4 economic model.
Our most recently calculated clean up costs for a sabotage attack on a truck and rail cask transporting nuclear fuel (Tables 6 and 7) greatly surpass the previously calculated clean up costs calculated by both RADTRAN 4 and RADTRAN 5. Our most recent clean up costs were calculated using RISKIND 2.0 which allowed us to use more precise calculation parameters than those inherently presented in the RADTRAN 4 and RADTRAN 5 economic models. RISKIND 2.0 allowed us to account for the average wind speed, wind direction, and meteorological conditions of the specific location of Las Vegas. It also allowed us to geographically map and calculate the Cs-137 surface contamination levels of the areas covered by a contamination plume dispersed as a result of a sabotage attack on a truck or rail cask transporting spent nuclear fuel. These calculated areas were then classified as either heavily, moderately, or lightly contaminated based on the clean up categories presented in the SAND96-0957 document to more precisely estimate the clean up cost of the entire affected area. Figures 5 and 6 display the contamination plume overlaying Las Vegas for both a truck and rail cask sabotage attack. Each isopleth is designated as either lightly, moderately, or heavily contaminated.

Our most recently calculated clean up cost for a sabotage attack on a truck cask transporting spent nuclear fuel through Las Vegas is 21 times greater than the estimated cost calculated by RADTRAN 4, and 10 times greater than the estimated cost calculated by RADTRAN 5. But as stated above, the full costs we have estimated only extend to 80 km. The largest differences between our most recent and previously estimated clean up costs can be seen in the rail cask sabotage scenarios. Our most recently calculated clean up cost for a sabotage attack on a rail cask transporting spent nuclear fuel is 186 times greater than the estimated cost calculated by RADTRAN 4, and 92 times greater than the calculated cost of RADTRAN 5.

There are several differences between the factors and fuel descriptions that went into our most recent calculations and those that were used in the previously calculated clean up costs that must be considered. However, the differences we have accounted for in our most recent calculations follow the guidelines presented by the DOE in its SEIS[22]. In our current calculations, the spent nuclear fuel has a shorter cooling period of 10 years in comparison to the previous cooling period of 15 years, which would increase the activity of Cs-137 in the cask inventory by up to 11%. The current fuel used to calculate our current clean up costs has a greater burnup, 60 GWD/TMU, than the previously used fuel which had a burnup of 50 GWD/MTU. This change also signifies that the fuel in the cask inventory will be hotter and will have a greater activity than the fuel used to calculate our previous cost estimates. In our previous report, it was assumed that the sabotage attack weapon only penetrated one side of the truck and rail cask, and in our most recent calculations, we assumed that the sabotage weapon used penetrates both sides of the truck and rail cask, creating an exit hole for the cask inventory, allowing more of the cask inventory to be released from the cask. Differences in release heights from the sabotaged truck and rail casks can also be accounted for in our most recent clean up cost estimates. In our most recent report, we assume that the weapon used to sabotage a truck cask penetrates the cask wall at the center of the cask, or at 1.5 meters above the ground. We assume the same for the rail cask, which places the center of the cask at 2.5 meters above the ground. The previously used release heights for the truck and rail casks were 1.508 and 2.08 meters, respectively.

Cost Underestimate Considerations

Due to reasons presented in the SAND96-0957 document[23], our calculated clean up cost estimates for Las Vegas are greatly underestimated. Our most recent clean up costs for a truck and rail cask sabotage attack, calculated according to the clean up categories presented in the SAND96-0957 document, are "well-founded estimates" but in no way serve as an upper bound of the potential remedial costs of a sabotage attack on a truck or rail cask transporting spent nuclear fuel through Las Vegas.

For each of the clean up costs associated with areas designated as lightly, moderately, and heavily contaminated, a specific time period is assumed for the completion of clean up. For lightly contaminated areas, it is assumed that all clean up will be carried out within a period of 3 months; the first month for planning, the second month for clean up, and the third month for certification and the resettling of inhabitants. For moderately contaminated areas, a clean up period of 6 months is assumed, as well as an assumed clean up period of 1 year for areas that are designated as heavily contaminated. Given the size of the areas that qualify as lightly, moderately, and heavily contaminated, listed in Tables 6 and 7, it is unlikely that these areas will be completely decontaminated and resettled within the time frames designated to each of the clean up categories. It could take months, even years, for the multiple parties involved in forming clean up strategies to agree on their plans, and years for completed clean up action to be carried out.

[22] USDOE, 2008.
[23] SAND96-0957. Appendix G.

There are several other areas in which the estimated clean up costs stated in the SAND96-0957 document lack realistic cost parameters that would have to be included in the clean up costs of the Las Vegas area. For one, the cost estimates for mixed-use urban areas do not include downtown business districts or high-rise apartment buildings[24]. Las Vegas is covered by high-rise casinos, hotels, business offices, and apartment buildings, and the inclusion of these buildings in decontamination plans would increase the cost of clean up.

The cost of on-site clean up is included in the total remedial cost, but the cost of evacuating, decontaminating, and monitoring the populace affected by the contamination plume dispersed from the sabotaged rail or truck cask is not included in the overall estimated clean up costs. This cost, however, would be minor in relation to other factors considered, but it is a factor that cannot be ignored and will still contribute to total clean up costs.

The total clean up cost estimates given in SAND96-0957 are also based on the monetary amounts that competitive contractors would bid for similar projects[25]. The idea of working in an area that is radioactively contaminated may cause many workers to increase their cost of payment. Supplying workers with newly required equipment, such as protective clothing and filtered breathing apparatuses, will also increase the cost of clean up[26]. The location of Las Vegas in relation to other populated areas could also affect the total clean up cost. Man-power, equipment, and equipment suppliers may be scarce in the areas surrounding Las Vegas, and the import of workers and equipment from outside cities for a clean up period of up to one year would greatly increase the cost of clean up. Along with an increase in worker pay and equipment cost, Chanin and Murfin's cost estimate did not account for the inclusion of health physics programs to ensure that occupational exposures to the radioactive contamination are monitored[27].

The costs of rerouting traffic and setting up detours were also not included in the cost estimates. As seen in Figures 5 and 6, a contamination plume from a sabotage attack in Las Vegas would lie directly over Interstate 15, as well as some of the smaller roads used to travel outside of Las Vegas, such as Lake Mead Boulevard, Las Vegas Boulevard, and Interstate 95. Evacuation routes avoiding these affected roadways would have to be planned out, and the cost of constructing a detour could be as high as $235 per meter of detour length (6-2). The decontamination of these roadways, especially Interstate 15 which lies directly along the center of heavily contaminated isopleths, could involve the use of fixatives such as road oils or organic binders. Water was the only fixative considered in the given cost estimates, and the use of non-water fixatives would increase the cost of decontamination[28].

[24] SAND96-0957, p. 6-2.
[25] SAND96-0957, p. F-3.
[26] SAND96-0957, p. F-9.
[27] SAND96-0957, p. F-9.
[28] SAND96-0957, p. F-4.

Government overhead costs, such as the cost of overseeing the work to be completed, were also not included in the cost estimates. Past radioactive decontamination projects suggest that the total government overhead cost could be as great as the actual cost of the clean up work, and Chanin and Murfin believe it would be reasonable to double the cost estimates to cover the costs of all indirect costs associated with clean up[29]. This would put the total clean up costs of a sabotage attack on a truck and rail car transporting spent nuclear fuel through Las Vegas at $926,643,121,529.55 and $1,295,056,713,058.05, respectively.

It also must be considered that our calculated clean up costs are extremely underestimated due to the limitations of the RISKIND and Hotspot computer programs. The moderately and lightly contaminated surface areas used to calculate the total clean up costs do not account for the total areas that would be contaminated as a result of a Cs-137 contamination plume released from a sabotaged truck or rail cask transporting spent nuclear fuel. The total areas of those surfaces designated as moderately and lightly contaminated could not be calculated through the use of RISKIND or Hotspot, and the limitations of the Hotspot program lets us know that the farthest distance the moderately and lightly contaminated isopleths could reach is beyond the distance of 200 km downwind of the sabotaged truck or rail cask. The actual areas covered by these moderate and light contamination levels would be much greater than the areas that were used to calculate our most recent clean up costs, therefore greatly increasing the cost of clean up. In addition, RADTRAN 4 and 5 have population densities ¼ the projected population density in 2067.

Radiation Exposures

Population Exposure

In this section we compare the radiation exposures to the urban population and surrounding population areas out to 80 km in the SEIS with our results in a sabotage event. The SEIS assumes material is released from the entrance hole whereas we assume a release from an exit hole, what we call a 2-hole event. The RWMA and SEIS fuel burnups (60,000 MWD/MTU) and cool down periods (10 years) are the same; the assumed population densities constitute an average of 20 of the largest cities in the United States are also the same. The meteorology (Pasquill Category D) and wind speed (4.47 m/s for Las Vegas) are also the same. To ensure that our methodology is the same as the SEIS, we reproduced the SEIS numbers for a 26 PWR fuel assembly rail cask and a 4 PWR fuel assembly truck cask. The population exposure results for the SEIS for truck and rail casks appear in Tables 9a and 9b below. Note that even though the rail cask has 6 ½ times the inventory of the truck cask, the population exposures from a truck cask (47,000 person-rems) are greater than for a

[29] SAND96-0957, p. 6-2, F-3.

rail cask (32,000 person-rems), according to the SEIS. This is an upshot of DOE's assumption that in a sabotage event with no exit hole, the internal pressurization within a rail cask is less than for a truck cask, and therefore the blowdown releases are less. For a rail cask, according to DOE, more of the pressurization from the broken fuel rods is absorbed or diluted by the larger internal space of a rail cask. Note also that the population exposure is due to respirable and non-respirable particulates. The respirable particles have a deposition velocity 1 cm/sec; the primary exposure from respirable particles is due to inhalation during the passing cloud.

Table 9a. SEIS Population Dose for Truck Sabotage Event

Respirable Acute Dose Ring Letter	Radius (km)	Donut Area (km^2)	Revised Pop Den ($persons/km^2$)	Release Height 1m	Release Height 16m	Release Height 32m	Release Height 48m	Release Height 64m	Totals (person-rem)
A	8.05	203.33	5012	7.46E+02	2.11E+03	7.93E+02	9.02E+02	4.38E+02	4.99E+03
B	16.09	609.99	2956	1.26E+02	4.96E+02	1.49E+02	1.90E+02	1.01E+02	1.06E+03
C	24.14	1016.65	2112	6.04E+01	2.26E+02	8.20E+01	1.06E+02	5.67E+01	5.31E+02
D	32.18	1423.31	1342	2.84E+01	1.06E+02	5.08E+01	6.50E+01	3.48E+01	2.85E+02
E	40.23	1829.98	899	1.52E+01	5.72E+01	3.33E+01	4.26E+01	2.28E+01	1.71E+02
F	80.45	15249.76	390	2.59E+01	1.01E+02	7.66E+01	9.82E+01	5.27E+01	3.54E+02
									7.39E+03
Non-Resp Long-Term Dose Ring Letter	**Radius (km)**	**Donut Area (km^2)**	**Revised Pop Den ($persons/km^2$)**	**Release Height 1m**	**Release Height 16m**	**Release Height 32m**	**Release Height 48m**	**Release Height 64m**	**Totals (person-rem)**
A	8.05	203.33	5012	1.25E+03	6.71E+03	8.94E+03	1.10E+04	5.31E+03	3.32E+04
B	16.09	609.99	2956	3.38E+01	3.51E+02	9.54E+02	1.72E+03	1.17E+03	4.23E+03
C	24.14	1016.65	2112	1.54E+01	8.24E+01	2.79E+02	5.23E+02	3.73E+02	1.27E+03
D	32.18	1423.31	1342	4.41E+00	2.32E+01	8.57E+01	1.68E+02	1.22E+02	4.03E+02
E	40.23	1829.98	899	1.47E+00	7.83E+00	3.21E+01	6.34E+01	4.76E+01	1.52E+02
F	80.45	15249.76	390	9.16E-01	4.99E+00	2.50E+01	4.98E+01	3.88E+01	1.20E+02
									3.94E+04
								Total	**4.68E+04**

Table 9b. SEIS Population Dose for Rail Sabotage Event

Respirable Acute Dose Ring Letter	Radius (km)	Donut Area (km^2)	Revised Pop Density ($Persons/km^2$)	Release Height 1m	Release Height 16m	Release Height 32m	Release Height 48m	Release Height 64m	Totals (person-rem)
A	8.05	203.33	**5012**	1.09E+02	3.26E+02	3.43E+02	3.69E+02	1.68E+02	1.32E+03
B	16.09	609.99	**2956**	1.80E+01	7.61E+01	1.01E+02	1.34E+02	7.20E+01	4.01E+02
C	24.14	1016.65	**2112**	8.11E+00	3.45E+01	4.67E+01	6.28E+01	3.46E+01	1.87E+02
D	32.18	1423.31	**1342**	3.79E+00	1.62E+01	2.26E+01	3.06E+01	1.70E+01	9.02E+01
E	40.23	1829.98	**899**	2.02E+00	8.72E+00	1.24E+01	1.69E+01	9.46E+00	4.95E+01
F	80.45	15249.76	**390**	3.43E+00	1.52E+01	2.26E+01	3.09E+01	1.74E+01	8.95E+01
									2.13E+03
Non-Resp Long-Term Dose Ring Letter	**Radius (km)**	**Donut Area (km^2)**	**Donut Pop Density ($Persons/km^2$)**	**Release Height 1m**	**Release Height 16m**	**Release Height 32m**	**Release Height 48m**	**Release Height 64m**	**Totals (person-rem)**
A	8.05	203.33	**5012**	9.54E+02	5.04E+03	6.69E+03	8.21E+03	3.98E+03	2.49E+04
B	16.09	609.99	**2956**	1.96E+01	2.63E+02	7.15E+02	1.29E+03	8.77E+02	3.16E+03
C	24.14	1016.65	**2112**	4.26E+00	6.20E+01	2.09E+02	3.92E+02	2.79E+02	9.46E+02
D	32.18	1423.31	**1342**	1.15E+00	1.74E+01	6.43E+01	1.26E+02	9.11E+01	3.00E+02
E	40.23	1829.98	**899**	3.57E-01	5.91E+00	2.41E+01	4.75E+01	3.56E+01	1.13E+02
F	80.45	15249.76	**390**	1.98E-01	3.77E+00	1.88E+01	3.74E+01	2.91E+01	8.93E+01
									2.95E+04
								Total	**3.16E+04**

The non-respirable particles have a deposition velocity of 10 cm/sec; the greatest population exposure is closer to the sabotage event, within the A population ring; the exposure is primarily due to 1-year direct gamma groundshine. Note also that a 1-hole sabotage event has differing release heights: 1 m (4%), 16 m (16%), 32 m (25%), 48 m (35%) and 64 m (20%). The percents are the relative contributions at the different heights. For a sabotage event with an exit hole, what we call a 2-hole event, we assume one release height, at the center of the cask.

Our calculations for a sabotage event with an exit hole, appear in Tables 10a and 10b below.

Table 10a. Population Exposure. Truck Sabotage with Exit Hole

Pop Exp Ring Letter	Distance (km)	Pop Dens (pers/km^2)	Resp Exp (pers-rems)	Nonresp Exp (pers-rems)	Total
A	0.05 – 8.05	5012	1.80E+06	2.63E+05	2.06E+06
B	8.05 – 16.09	2956	2.95E+05	5.37E+03	3.00E+05
C	16.09 – 24.14	2112	1.34E+05	1.31E+03	1.35E+05
D	24.14 – 32.18	1342	6.32E+04	3.91E+02	6.36E+04
E	32.18 – 40.23	899	3.48E+04	1.67E+02	3.50E+04
F	40.23 - 80	390	6.15E+04	1.13E+02	6.16E+04
		Total	2.39E+06	2.70E+05	**2.66E+06**

Table 10b. Population Exposure. TAD Rail Cask Sabotage with Exit Hole

Pop Exp Ring Letter	Distance (km)	Pop Dens (pers/km^2)	Resp Exp (pers-rems)	Nonresp Exp (pers-rems)	Total
A	0.05 – 8.05	5012	4.47E+06	4.87E+05	4.96E+06
B	8.05 – 16.09	2956	7.45E+05	1.05E+04	7.56E+05
C	16.09 – 24.14	2112	3.36E+05	2.49E+03	3.38E+05
D	24.14 – 32.18	1342	1.61E+05	8.01E+02	1.62E+05
E	32.18 – 40.23	899	8.66E+04	2.78E+02	8.69E+04
F	40.23 - 80	390	1.53E+05	1.87E+02	1.53E+05
		Total	5.95E+06	5.01E+05	**6.45E+06**

As seen, in a sabotage event with an exit hole, the population exposures from the 21 PWR fuel assembly TAD rail cask are greater than for the truck cask.

In Table 11 below, we compare the SEIS calculations without an exit hole to our calculations with an exit hole.

Table 11. Comparison Population Exposures. Sabotage Event with and without an Exit Hole

	SEIS No Exit Hole (Pers-rems)	RWMA With Exit Hole (Pers-rems)
Rail*	32,000	6,450,000
Truck	47,000	2,660,000

* SEIS rail cask has 26 PWR fuel assemblies; the TAD rail cask has 21 fa.

As seen, a sabotage event with an exit hole has a much greater population exposure, more than a factor of 50 greater, due to a much greater radionuclide release. Though we have not carried out the calculations in this report, the radionuclide release for a pressurized rail cask with only an entrance hole would also have a much greater population exposure than the above SEIS population exposures. The SEIS population exposures are based on fuel assemblies being pressurized and not the cask itself, which is not the physical reality. The Holtec HI-STAR cask, for example, is pressurized to 100 psig, implying the blowdown effect would be much greater, and also implying that the rail cask would have a greater release than the truck cask.

Maximum Exposed Individual

In this section we compare the radiation exposure to the maximum exposed individual (MEI). The SEIS considers the MEI residing at 100 meters from the sabotage event. The exposure is due to inhalation of the passing cloud, and a long-term 1-year exposure, due to groundshine. As seen in Table 12, the exit hole produces exposures that are 500 to 1000 times greater than those without an exit hole.

Table 12. Comparison MEI Sabotage Event W/ and W/O Exit Hole

	SEIS w/out Exit Hole (rems)	RWMA w/ Exit Hole (rems)
Rail	27.08	43,800
Truck	43.25	24,000

The calculated dose to the maximum exposed individual at 100 m is for a time period of one year and is primarily due to groundshine, direct gamma from deposited radionuclides. But the acute doses that occur within the immediate aftermath of a sabotage event due to passage of the radioactive cloud are primarily due to inhalation, as shown in Table 13 below. In Table 13 we have separated out the acute doses, within the first two hours of a sabotage event, from the one year doses.

Table 13. MEI Acute Doses at 100 m
Sabotage Event w/ Exit Hole

		Truck (rems)	Rail (rems)
Respirable	Inhalation	600	1380
	Groundshine	4	10
	Cloudshine	3	6
Non-Respirable	Groundshine	5	2
	Total	**612**	**1398**

As seen, the greatest contributor to the acute dose at 100 m is inhalation of the passing cloud. Groundshine is also important, particularly if a person remains for 1 year, since the direct gamma dose rate is 5 rems/hour (rail). Groundshine is essentially an X-ray machine that cannot be turned off. Over a one year period, the direct gamma doses can exceed 20,000 rems to a person residing at 100 meters from a truck sabotage event and double that for a rail sabotage event..

High acute radiation doses due to inhalation have important implications for first responders and residents near the sabotage event. Since the greatest contributor to the acute dose is inhalation, persons should remain indoors till the radiation cloud passes, to avoid inhaling radioactive material. Following the passage of the radioactive cloud, residents should be evacuated since the direct gamma dose rate is 5 rem/hr (truck) and 12 rem/hour (rail). First responders should not enter near the sabotage event without self-contained breathing apparatus. In the longer term, because of the high direct gamma dose rates near the event, the command center should obviously be established upwind.

According the US Environmental Protection Agency's (EPA) Manual of Protective Action Guides and Protection Actions for Nuclear Incidents, sheltering is the preferred protective action when the primary risk comes from the inhalation of radioactive particulates in short-term plumes. There is no recognized threshold for the minimum level at which sheltering should be implemented, but the minimum threshold for evacuation is 1 rem. Additional thought should be given to disseminating information to those affected in sheltering to limit air exchange rates by sealing cracks and openings with cloth, weather stripping, or tape and to use wet towels or handkerchiefs as a mask to filter inhaled air. The US EPA recommends that sheltered buildings should be opened to reduce the airborne activity trapped inside and that individuals should leave the high exposure areas as soon as possible following the cloud passage to avoid further exposure from deposited radioactive materials.[30]

The dose limits recognized by the US EPA for workers performing emergency services are as follows:

- 5 rem dose limit for all activities

[30] US Environmental Protection Agency. 1992. Manual of Protective Action Guides and Protection Actions for Nuclear Incidents, Second Printing.

- 10 rem dose limit for protecting valuable property
- 25 rem dose limit for life saving or protection of a large population
- >25 rem for life saving or protection of large populations only on a voluntary basis when the individual has been fully informed of the risks involved.

These doses could easily be exceeded for emergency workers in the sabotage events discussed above. The US EPA further recommends that prophylactic administration of potassium iodide be considered as a thyroid blocking agent to workers performing emergency services and other relevant groups receiving whole-body doses greater than 25 rem.[31]

In Table 14, we list the expected health effects associated with whole body absorbed doses received within a few hours as recognized by the US EPA. Prodromal effects are forewarning symptoms of more serious health effects associated with large doses of radiation.[32]

Table 14. Health Effects Associated with Whole-Body Absorbed Doses Received Within a Few Hours[33]

Whole Body Dose (rem)	Early Fatalities
140	5%
200	15%
300	50%
400	85%
460	95%
Whole Body Dose (rem)	**Prodromal Effects**
50	2%
100	15%
150	50%
200	85%
250	98%

[31] USEPA; 1992.
[32] USEPA; 1992.
[33] USEPA; 1992.

Figure 5a. Cs-137 Surface Concentrations: Truck Sabotage Attack, Las Vegas, Nevada

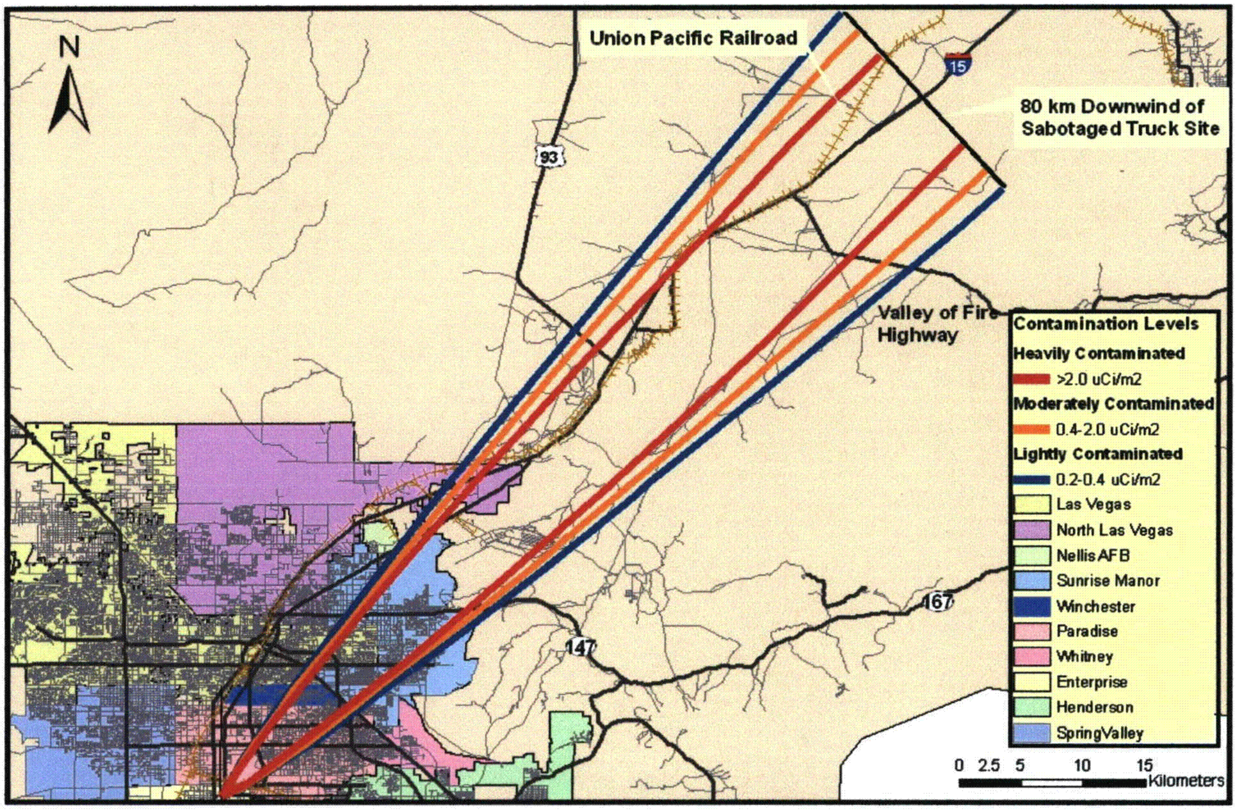


Figure 5b. Cs-137 Surface Concentrations: Truck Sabotage Attack, Las Vegas, Nevada

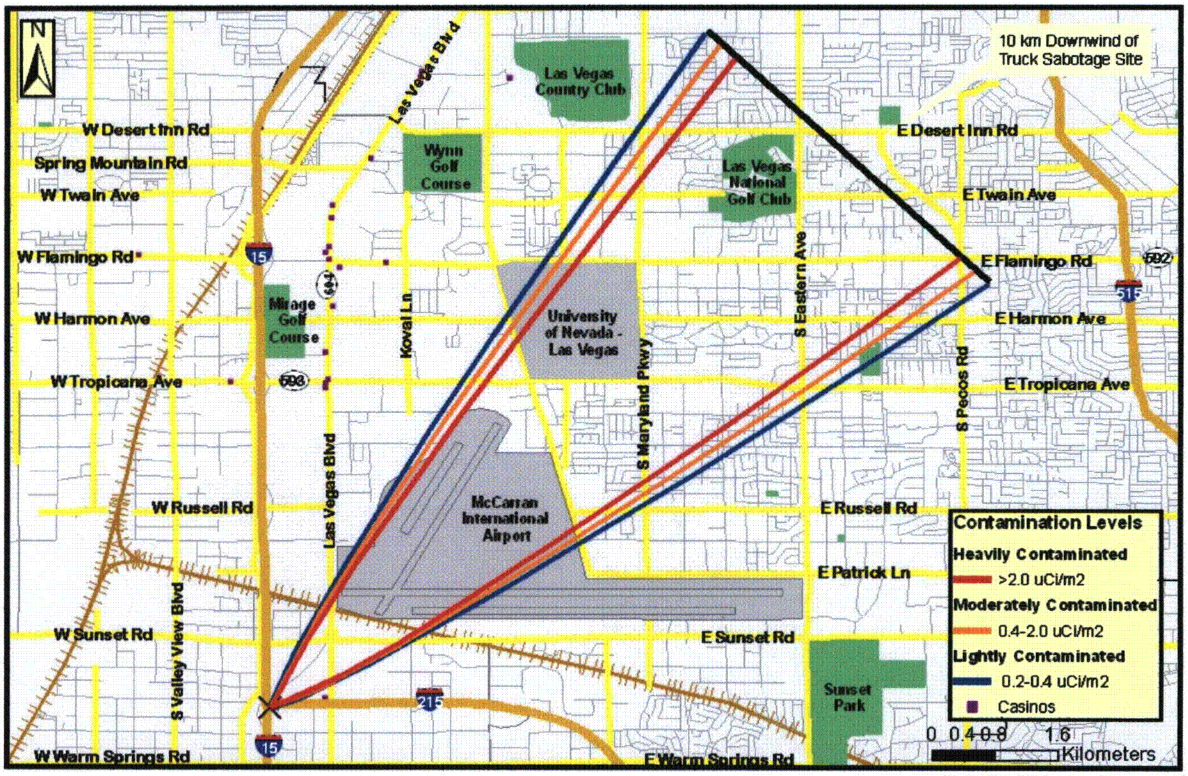


Figure 6a. Cs-137 Surface Concentrations: Rail Sabotage Attack, Las Vegas, Nevada

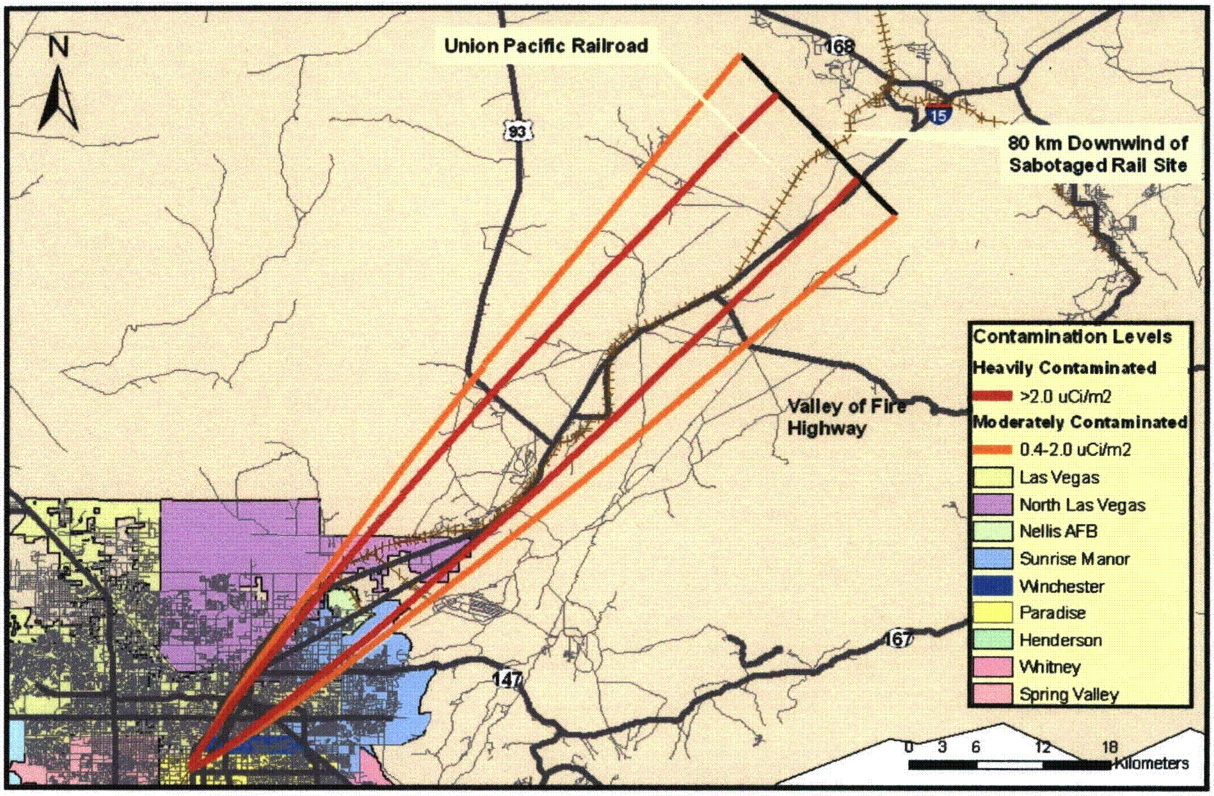
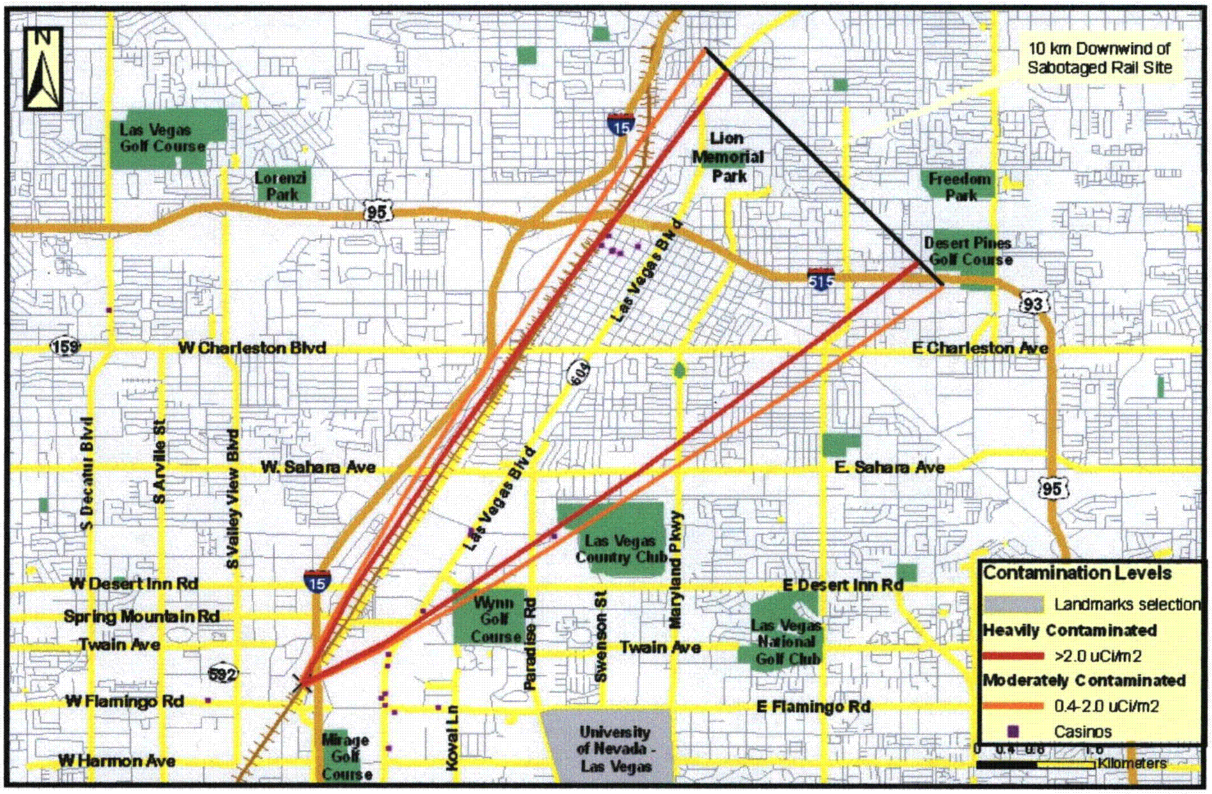


Figure 6b. Cs-137 Surface Concentrations: Rail Sabotage Attack, Las Vegas, Nevada



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Rulemaking Comments

From:	Joe Strolin [jstrolin@nuc.state.nv.us]
Sent:	Friday, April 08, 2011 2:49 PM
To:	Rulemaking Comments
Cc:	Bob Halstead - AOL
Subject:	State of Nevada Comments on NRC Proposed Rule: Physical Protection of Irradiated Reactor Fuel in Transit
Attachments:	State of Nevada Comments 10 CFR Part 73.37.pdf

Attached please find the State of Nevada's comments on NRC proposed rule on the Physical Protection of Irradiated Reactor Fuel in transit. These comments are submitted in response to the October 13, 2010 Federal Register Notice (75 FR 62695-62716). Nevada appreciates the extension of the comment deadline through April 11, 2011.

Please acknowledge receipt of the comments by replying to this email or by calling the Nevada Agency for Nuclear Projects at 775-687-3744.

Sincerely,

Joseph C. Strolin, Acting Executive Director
Nevada Agency for Nuclear Projects
Office of the Governor
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