Table IV-2
Some Categories of Risk Posed by a Commercial Nuclear Facility

Category	Definition	Mechanisms
Radiological risk	Potential for harm to humans as a result of unplanned exposure to ionizing radiation	Exposure arising from: • Release of radioactive material via air or water pathways, or • Line-of-sight exposure to unshielded radioactive material or a criticality event
Proliferation risk	Potential for diversion of fissile material or radioactive material to weapons use	Diversion by: • Non-State actors who defeat safeguards procedures and devices, or • The host State
Program risk	Potential for facility function to diverge substantially from original design objectives	Functional divergence due to: • Failure of facility to enter service or operate as specified, or • Policy or regulatory shift that alters design objectives or facility operation, or • Changed economic and societal conditions, or • Conventional accident or attack affecting the facility

Notes:
(a) In this declaration, the general term "risk" is defined as the potential for an unplanned, undesired outcome. There are various categories of risk, including the three categories in this table.
(b) In the case of radiological risk, the events leading to unplanned exposure to radiation could be conventional accidents or attacks.
(c) The term "proliferation risk" is often used to refer to the potential for diversion of fissile material, for use in nuclear weapons. Here, the term also covers the potential for diversion of radioactive material, for use in radiological weapons.

Table IV-3
Potential Sabotage Events at an SNF Storage Pool, as Postulated in the NRC's August 1979 Generic EIS on Handling and Storage of Spent LWR Fuel

Event Designator	General Description of Event	Additional Details
Mode 1	• Between 1 and 1,000 fuel assemblies undergo extensive damage by high-explosive charges detonated under water • Adversaries commandeer the central control room and hold it for approx. 0.5 hr to prevent the ventilation fans from being turned off	• One adversary can carry 3 charges, each of which can damage 4 fuel assemblies • Damage to 1,000 assemblies (i.e., by 83 adversaries) is a "worst-case bounding estimate"
Mode 2	• Identical to Mode 1 except that, in addition, an adversary enters the ventilation building and removes or ruptures the HEPA filters	
Mode 3	• Identical to Mode 1 within the pool building except that, in addition, adversaries breach two opposite walls of the building by explosives or other means	• Adversaries enter the central control room or ventilation building and turn off or disable the ventilation fans
Mode 4	• Identical to Mode 1 except that, in addition, adversaries use an additional explosive charge or other means to breach the pool liner and 1.5 m-thick concrete floor of the pool	

Notes:
(a) Information in this table is from Appendix J of: NRC, 1979.
(b) The postulated fuel damage ruptures the cladding of each rod in an affected fuel assembly, releasing "contained gases" (gap activity) to the pool water, whereupon the released gases bubble to the water surface and enter the air volume above that surface.

Table V-1
Future World Scenarios Identified by the Stockholm Environment Institute

Scenario	Characteristics
Conventional Worlds	
Market Forces	Competitive, open, and integrated global markets drive world development. Social and environmental concerns are secondary.
Policy Reform	Comprehensive and coordinated government action is initiated for poverty reduction and environmental sustainability.
Barbarization	
Breakdown	Conflict and crises spiral out of control and institutions collapse.
Fortress World	This scenario features an authoritarian response to the threat of breakdown, as the world divides into a kind of global apartheid with the elite in interconnected, protected enclaves and an impoverished majority outside.
Great Transitions	
Eco-Communalism	This is a vision of bio-regionalism, localism, face-to-face democracy and economic autarky. While this scenario is popular among some environmental and anarchistic subcultures, it is difficult to visualize a plausible path, from the globalizing trends of today to eco-communalism, that does not pass through some form of barbarization.
New Sustainability Paradigm	This scenario changes the character of global civilization rather than retreating into localism. It validates global solidarity, cultural cross-fertilization and economic connectedness while seeking a liberatory, humanistic, and ecological transition.

Source: Raskin et al, 2002

Table VI-1
Potential Types of Attack on an SNF Storage Facility Leading to Atmospheric Release of Radioactive Material

Type of Event	Facility Behavior	Some Relevant Instruments and Modes of Attack	Characteristics of Atmospheric Release
Type 1: Vaporization or Pulverization	• All or part of facility is vaporized or pulverized	• Facility is within the fireball of a nuclear-weapon explosion	• Radioactive material in facility is lofted into the atmosphere and amplifies fallout from nuc. explosion
Type 2: Rupture and Dispersal (Large)	• Facility structures are broken open • Fuel is dislodged from facility and broken apart • Some ignition of zircaloy fuel cladding may occur, typically without sustained combustion	• Aerial bombing • Artillery, rockets, etc. • Effects of blast etc. outside the fireball of a nuclear-weapon explosion	• Solid pieces of various sizes are scattered in vicinity • Gases and small particles form an aerial plume that travels downwind • Some release of volatile species (esp. Cesium-137) if zirc. combustion occurs
Type 3: Rupture and Dispersal (Small)	• Facility structures are penetrated but retain basic shape • Fuel may be damaged but most rods retain basic shape • Damage to cooling systems could lead to zirc. combustion	• Vehicle bomb • Impact by commercial aircraft • Perforation by shaped charge	• Scattering and plume formation as in Type 2 event, but involving smaller amounts of material • Substantial release of volatile species if zirc. combustion occurs
Type 4: Precise, Informed Targeting	• Facility structures are penetrated, creating a release pathway • Zirc. combustion is initiated indirectly by damage to cooling systems, or by direct ignition	• Missiles (military or improvised) with tandem warheads • Close-up use of attack instruments (e.g., shaped charge, incendiary, thermic lance)	• Scattering and plume formation as in Type 3 event • Substantial release of volatile species, potentially exceeding amount in Type 3 release

Table VI-2
The Shaped Charge as a Potential Instrument of Attack

Category of Information	Selected Information in Category
General information	• Shaped charges have many civilian and military applications, and have been used for decades • Applications include human-carried demolition charges or warheads for anti-tank missiles • Construction and use does not require assistance from a government or access to classified information
Use in World War II	• The German MISTEL, designed to be carried in the nose of an un-manned bomber aircraft, is the largest known shaped charge • Japan used a smaller version of this device, the SAKURA bomb, for kamikaze attacks against US warships
A large, contemporary device	• Developed by a US government laboratory for mounting in the nose of a cruise missile • Described in detail in an unclassified, published report (citation is voluntarily withheld here) • Purpose is to penetrate large thicknesses of rock or concrete as the first stage of a "tandem" warhead • Configuration is a cylinder with a diameter of 71 cm and a length of 72 cm • When tested in November 2002, created a hole of 25 cm diameter in tuff rock to a depth of 5.9 m • Device has a mass of 410 kg; would be within the payload capacity of many general-aviation aircraft
A potential delivery vehicle	• A Beechcraft King Air 90 general-aviation aircraft can carry a payload of up to 990 kg at a speed of up to 460 km/hr • The price of a used, operational King Air 90 in the USA can be as low as $0.4 million

Source:
This table is adapted from Table 7-6 of: Thompson, 2009.

Table VI-3
Performance of US Army Shaped Charges, M3 and M2A3

Target Material	Indicator	Value for Stated Type of Shaped Charge	
		Type: M3	**Type: M2A3**
Reinforced concrete	Maximum wall thickness that can be perforated	150 cm	90 cm
	Depth of penetration in thick walls	150 cm	75 cm
	Diameter of hole	• 13 cm at entrance • 5 cm minimum	• 9 cm at entrance • 5 cm minimum
	Depth of hole with second charge placed over first hole	210 cm	110 cm
Armor plate	Perforation	At least 50 cm	30 cm
	Average diameter of hole	6 cm	4 cm

Notes:
(a) Data are from US Army Field Manual FM 5-25: Army, 1967, pp 13-15 and page 100.
(b) The M2A3 charge has a mass of 5 kg, a maximum diameter of 18 cm, and a total length of 38 cm including the standoff ring.
(c) The M3 charge has a mass of 14 kg, a maximum diameter of 23 cm, a charge length of 39 cm, and a standoff pedestal 38 cm long.

Table VII-1
Estimated Duration of Phases of Implementation of the Yucca Mountain Repository

<table>
<tr><th colspan="2" rowspan="2">Phase of Repository Implementation</th><th colspan="2">Duration of Phase (years)</th></tr>
<tr><th>If Yucca Mountain total inventory of commercial spent fuel = 63,000 MTHM</th><th>If Yucca Mountain total inventory of commercial spent fuel = 105,000 MTHM</th></tr>
<tr><td colspan="2">Construction phase</td><td>5</td><td>5</td></tr>
<tr><td rowspan="3">Operation and monitoring phases</td><td>Development</td><td>22</td><td>36</td></tr>
<tr><td>Emplacement</td><td>24-50</td><td>38-51</td></tr>
<tr><td>Monitoring</td><td>76-300</td><td>62-300</td></tr>
<tr><td colspan="2">Closure phase</td><td>10-17</td><td>12-23</td></tr>
</table>

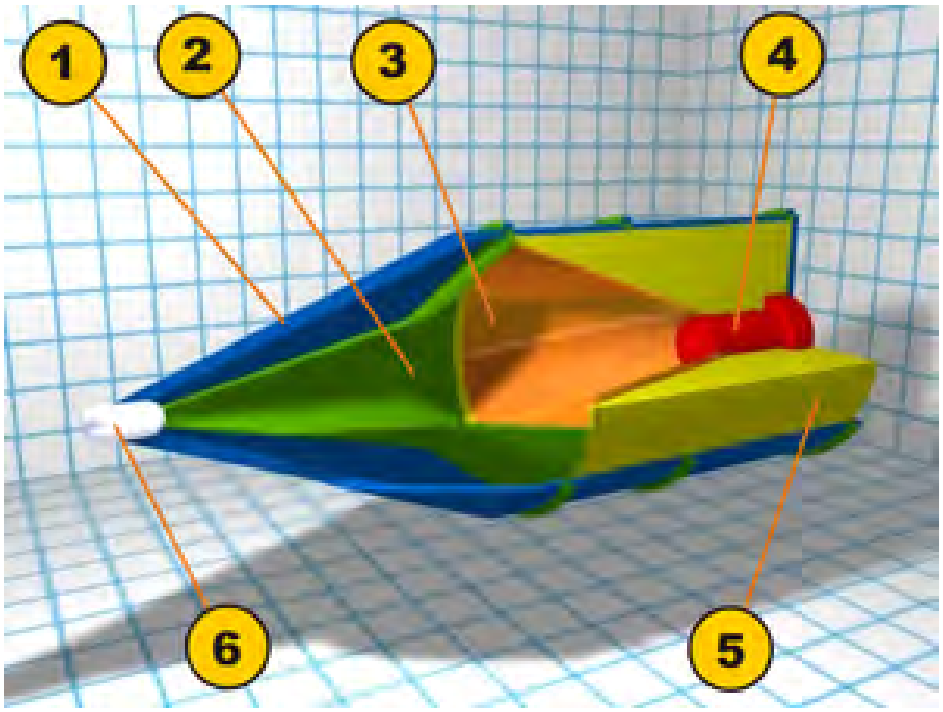
Notes:
(a) These estimates are from: DOE, 2002, Volume I, pages 8-8 and 2-18.
(b) The Development and Emplacement phases would begin on the same date. Other phases would be sequential.
(c) The Construction phase would begin with issuance of construction authorization, and end with issuance of a license to receive and dispose of radioactive waste.

Table IX-1
Selected Approaches to Protecting Critical Infrastructure in the USA From Attack by Non-State Actors, and Some Strengths and Weaknesses of these Approaches

Approach	Strengths	Weaknesses
Approach #1: Offensive military operations internationally	• Could deter or prevent governments from supporting non-State actors hostile to the USA	• Could promote growth of non-State groups hostile to the USA, and build sympathy for these groups in foreign populations • Could be costly in terms of lives, money, etc.
Approach #2: International police cooperation within a legal framework	• Could identify and intercept potential attackers	• Implementation could be slow and/or incomplete • Requires ongoing international cooperation
Approach #3: Surveillance and control of the domestic population	• Could identify and intercept potential attackers	• Could destroy civil liberties, leading to political, social, and economic decline of the USA
Approach #4: Secrecy about design and operation of infrastructure facilities	• Could prevent attackers from identifying points of vulnerability	• Could suppress a true understanding of risk • Could contribute to political, social, and economic decline
Approach #5: Active defense of infrastructure facilities (by use of guards, guns, gates, etc.)	• Could stop attackers before they reach the target	• Requires ongoing expenditure & vigilance • May require military involvement
Approach #6: Robust and inherently-safer design of infrastructure facilities (**Note:** This approach could be part of a "protective deterrence" strategy for the USA.)	• Could allow target to survive attack without damage, thus contributing to protective deterrence • Could substitute for other protective approaches, avoiding their costs and adverse impacts • Could reduce risks from accidents & natural hazards	• Could involve higher capital costs

Notes:
(a) These approaches could be used in parallel, with differing weightings.
(b) Approach #6 would contribute to "protective deterrence", which is distinct from "counter-attack deterrence".

Figure VI-1
Schematic View of a Generic Shaped-Charge Warhead



Notes:
(a) Figure accessed on 4 March 2012 from: http://en.wikipedia.org/wiki/Shaped_charge
(b) Key:

Item 1: Aerodynamic cover
Item 2: Empty cavity
Item 3: Conical liner (typically made of ductile metal)
Item 4: Detonator
Item 5: Explosive
Item 6: Piezo-electric trigger

(c) Upon detonation, a portion of the conical liner would be formed into a high-velocity jet directed toward the target. The remainder of the liner would form a slower-moving slug of material.

Figure VI-2
MISTEL System for Aircraft Delivery of a Shaped Charge, World War II

Notes:
(a) Photograph accessed on 5 March 2012 from:
http://www.historyofwar.org/Pictures/pictures_Ju_88_mistel.html
(b) A shaped-charge warhead can be seen at the nose of the lower (converted bomber) aircraft, replacing the cockpit. The aerodynamic cover in front of the warhead would have a contact fuse at its tip, to detonate the shaped charge at the appropriate standoff distance.
(c) A human pilot in the upper (fighter) aircraft would control the entire rig, and would point it toward the target. Then, the upper aircraft would separate and move away, and the lower aircraft would be guided to the target by an autopilot.

Figure VI-3
January 2008 Test of a Raytheon Shaped Charge, Intended as the Penetration (Precursor) Stage of a Tandem Warhead System

Before Test

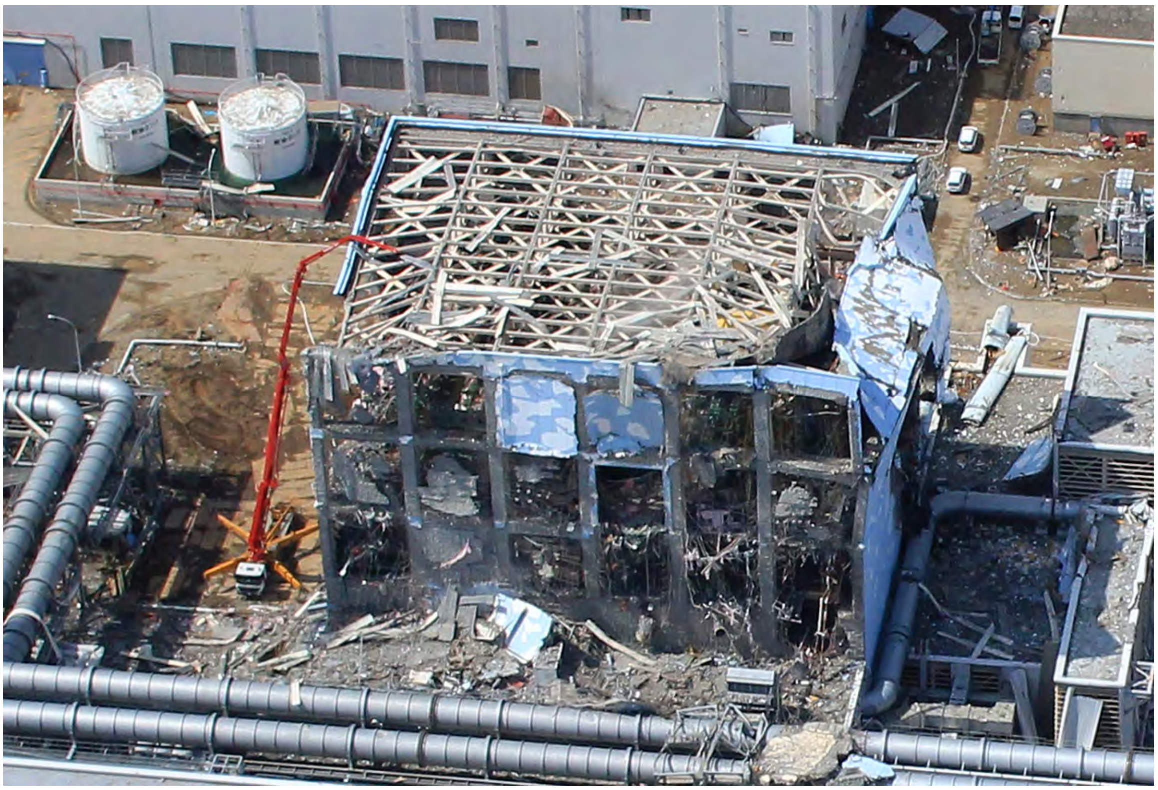
After Test (viewed from the attacked face)

Notes:
(a) These photographs are from: Raytheon, 2008. For additional, supporting information, see: Warwick, 2008.
(b) The shaped-charge jet penetrated about 5.9 m into a steel-reinforced concrete block with a thickness of 6.1 m. Although penetration was incomplete, the block was largely destroyed, as shown. Compressive strength of the concrete was 870 bar.
(c) The shaped charge had a diameter of 61 cm and contained 230 kg of high explosive. It was sized to fit inside the US Air Force's AGM-129 Advanced Cruise Missile.

Figure VI-4
Aftermath of a Small-Aircraft Suicide Attack on an Office Building in Austin, Texas, February 2010

Notes:
(a) Photograph and information in these notes are from: Brick, 2010.
(b) A major tenant of the building was the Internal Revenue Service (IRS).
(c) The aircraft was a single-engine, fixed-wing Piper flown by its owner, Andrew Joseph Stack III, an Austin resident who worked as a computer engineer.
(d) A statement left by Mr Stack indicated that a dispute with the IRS had brought him to a point of suicidal rage.

Figure VIII-1
Unit 4 at the Fukushima #1 Site During the 2011 Accident



Source:
Accessed on 20 February 2012 from Ria Novosti at:
http://en.rian.ru/analysis/20110426/163701909.html; image by Reuters Air Photo Service.

Figure VIII-2
Outcome of Test Burn of a BWR Fuel Assembly

Notes:

(a) This figure is from: Weber, 2011.

(b) The figure shows the outcome of a test to investigate the burning of SNF. An inactive 9x9 BWR fuel assembly with zircaloy-2 cladding was burned in air. The assembly was at reactor scale although not all rods were full length. The assembly was electrically heated (via 74 electric heater rods) at a rate of 5 kW.

(c) The fuel assembly was surrounded by thermal insulation – the white material in the photograph.

(d) This test did not attempt to simulate the release of Cesium or other materials from the damaged fuel.

DECLARATION OF PHILLIP MUSEGAAS REGARDING THE SCOPE OF THE PROPOSED WASTE CONFIDENCE ENVIRONMENTAL IMPACT STATEMENT

Under penalty of perjury, I, Phillip Musegaas, Esq., declare as follows:

Statement of Qualifications

1. I am the Hudson River Program Director for Riverkeeper, Inc. ("Riverkeeper"). I have been employed by Riverkeeper since August 2005. Riverkeeper is a 501(c)(3) non-profit, membership-supported environmental organization. Its mission is to protect the environmental, recreational and commercial integrity of the Hudson River and its tributaries, and safeguard the drinking water of nine million New York City and Hudson Valley residents.

2. Through my work at Riverkeeper, I have been involved with various legal and policy matters involving the Indian Point nuclear power plant. Generally, since its inception in 1966, Riverkeeper has used litigation, science, advocacy, and public education to raise and address concerns relating to Indian Point, which is located on the eastern bank of the Hudson River in Buchanan, NY. Riverkeeper is headquartered in Ossining, New York, approximately 10 miles from the Indian Point facility, and has numerous members that reside within at least fifty (50) miles of the plant. Since the terrorist attacks of September 11th, Riverkeeper has become increasingly concerned with the environmental, safety, and security issues presented by the large amount of irradiated ("spent") fuel stored onsite at the Indian Point facility. Indian Point Energy Center currently stores over 1,500 tons of spent fuel onsite, either in densely packed pools or in dry casks. This is one of the largest quantities of high level radioactive waste in the northeast. Moreover, the owner and operator of the plant, Entergy Nuclear Indian Point Unit 2, L.L.C. and Entergy Nuclear Indian Point Unit 3, L.L.C. ("Entergy") have applied for a twenty year license extension, which, if granted would result in an approximate 1,000 tons of additional spent fuel being produced and stored onsite, perhaps indefinitely.

The spent fuel pools ("SFPs") storing nuclear waste at Indian Point are vulnerable to environmental degradation and safety/security risks. The Indian Point SFPs have a documented history of leaking radioactive water to the environment. Around 2005, the owners of Indian Point "discovered" that SFP leaks, which began in the 1990s, were still occurring and had resulted in extensive contamination plumes in the groundwater beneath the site. Since this time, Riverkeeper has been actively involved in raising site-specific concerns about the environmental and safety implications of the SFP leakage at Indian Point, as well as more general concerns about the radiological leakage and contamination issues facing nuclear plants across the country and the inadequacy of the Nuclear Regulatory Commission's ("NRC") legal and regulatory framework for addressing such issues. This work, which I have been directly involved in while at Riverkeeper, includes the following:

- Riverkeeper successfully intervened in the Indian Point license renewal proceeding before the NRC, which was initiated in April 2007, and raised an adjudicable issue relating to the sufficiency of the environmental analysis afforded to the "newly discovered" SFP leaks and groundwater contamination occurring at Indian Point. This contention was proffered and accepted for adjudication pursuant to the National

Attachment 3
January 2, 2013

Environmental Policy Act ("NEPA"). While this contention ultimately (and recently) was subject to a settlement, Riverkeeper spent five years preparing to adjudicate this issue, reviewing thousands of Entergy and NRC documents related to the SFP leaks and groundwater contamination at Indian Point, and obtaining expert analyses pertaining to the likelihood of ongoing and future SFP leaks and the environmental consequences of SFP leaks at Indian Point.[1]

- As an intervenor, Riverkeeper raised a legal claim in New York State administrative permit proceedings relating to whether radiological leaks and groundwater contamination at Indian Point result in violations of relevant state requirements and standards. These proceedings are currently pending before the New York State Department of Environmental Conservation ("NYSDEC") and concern Entergy's application for a Water Quality Certification under Section 401 of the Clean Water Act, which was filed in April 2009 in connection with Entergy's Federal License Renewal Application to the NRC. In this proceeding, Riverkeeper once again invested a significant amount of time and obtained expert analyses pertaining to the relevant issues. This issue resulted in adjudicatory hearings and a voluminous record relating to the SFP leaks at Indian Point, the environmental impacts of the leaks to the groundwater and the Hudson River, the inadequacy of Entergy's programs for managing the aging of buried plant components and the likely future radiological leaks from such components, and the applicability of state water quality related standards to radiological leakage and contamination issues, as memorialized in Riverkeeper's post-hearing briefings on the issue.[2]

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[1] *See* Riverkeeper and Hudson River Sloop Clearwater Initial Statement of Position Regarding Consolidated Contention RK-EC-3/CW-EC-1 (Spent Fuel Pool Leaks) (December 22, 2011), at 29-37, *available at* ADAMS Accession No. ML12335A617 (hereinafter "Riverkeeper Statement of Position Regarding SFP Leaks Contention"); Prefiled Direct Testimony of Arnold Gundersen Regarding Consolidated Contention RK-EC-3/CW-EC-1 (Spent Fuel Pool Leaks) (December 21, 2011), *available at* ADAMS Accession No. ML12340A811; Prefiled Written Testimony of Gillian Stewart on Consolidated Contention RK-EC-3/CW-EC-1 - Spent Fuel Pool Leaks (December 22, 2011), *available at*, ADAMS Accession No. ML12335A586.

[2] In the Matter of a Renewal and Modification of a State Pollutant Discharge Elimination System ("SPDES") Permit Pursuant to Article 17 of the Environmental Conservation Law And Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York parts 704 and 750 *et seq.* by Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC, Permittee, DEC # 3-5522-00011/00004, SPDES # NY-0004472, and In the Matter of the Application by Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC, for a Certificate Pursuant to §401 of the Federal Clean Water Act, DEC # 3-5522-00011/00030, DEC # 3-5522-00011/00031, Post-Hearing Closing Brief of Intervenors Riverkeeper, Natural Resources Defense Council, and Scenic Hudson Regarding Issue for Adjudication No. 3 – Radiological Materials (April 27, 2012), *available at*, http://www.riverkeeper.org/wp-content/uploads/2012/12/2012.04.27.Indian-Point-401-SPDES-Proceedings-Riverkeeper-Closing-Brief-Radiological.pdf; In the Matter of a Renewal and Modification of a State Pollutant Discharge Elimination System ("SPDES") Permit Pursuant to Article 17 of the Environmental Conservation Law And Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York parts 704 and 750 *et seq.* by Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC, Permittee, DEC # 3-5522-00011/00004, SPDES # NY-0004472, and In the Matter of the Application by Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC, for a Certificate Pursuant to §401 of the Federal Clean Water Act, DEC # 3-5522-00011/00030, DEC # 3-5522-00011/00031, Post-Hearing Closing Reply Brief of Intervenors Riverkeeper, Natural Resources Defense Council, and Scenic Hudson Regarding Issue for Adjudication No. 3 – Radiological Materials (October 5, 2012), *available at*, http://www.riverkeeper.org/wp-content/uploads/2012/12/2012.10.05.Indian-Point-401-SPDES-Proceedings-Riverkeeper-Closing-Reply-Brief-Radiological.pdf. There has yet to be a final decision relating to this issue, as the State proceedings to which it is a part of remain ongoing.

- Riverkeeper has been a national stakeholder in NRC task force activities related to radiological leakage and environmental contamination issues occurring at nuclear plants across the country. In particular, in March 2010, NRC convened a team of agency staffers to evaluate actions taken in response to recent incidents of radiological leakage and determine what future actions are necessary.[3] Riverkeeper submitted various sets of comments to inform that iterative process,[4] and I have appeared as a panel member at multiple NRC task-force related meetings and workshops to discuss relevant concerns and recommendations.[5]

- Riverkeeper was consulted and provided feedback to the U.S. Government Accountability Office ("GAO") in relation to GAO's study of leaking underground piping systems at nuclear power plants. GAO's study resulted in the publication of a final report in June 2011.[6]

In addition to the extensive work Riverkeeper has done relating to radiological leakage and contamination issues, Riverkeeper has also been an engaged stakeholder in NRC's waste confidence related proceedings. Due to the high level of concern related to SFP leaks, and the safety and security implications of "temporary" nuclear waste storage at reactor sites, Riverkeeper has been an active voice in NRC proceedings on such matters. In 2009, Riverkeeper submitted comments on NRC's initial proposed "update" to the Waste Confidence Decision and Temporary Storage Rule.[7] Riverkeeper was also a party to the Federal appeal of the NRC's final rule concerning this "update," the outcome of which necessitates the instant EIS process. In addition, Riverkeeper has raised safety issues related to SFP storage and waste-confidence related issues in the Indian Point license renewal proceeding. Riverkeeper initially raised a contention relating to the risk of SFP fires and the inadequacy of Entergy's severe accident mitigation alternatives analysis.[8] This contention was supported by multiple expert analyses.[9] Riverkeeper has also raised a contention relating to the need for site-specific review

[3] Memorandum to B.S. Mallett (Deputy Executive Director for Reactor and Preparedness Programs), C.A. Casto (Deputy Regional Administrator, Region IV), from R.W. Borchardt (Executive Director for Operations), Subject: Groundwater Contamination Task Force (March 5, 2010), ADAMS Accession No. ML100640188.
[4] *See, e.g.*, Riverkeeper Comments For Senior Management Review of NRC Groundwater Task Force Report, Docket ID NRC-2010-0302 (November 1, 2010), ADAMS Accession No. ML103120555.
[5] *See, e.g.*, Riverkeeper, Inc., Spent Fuel Pool Leaks and Groundwater Contamination at Indian Point, Nuclear Regulatory Commission Public Meeting (April 20, 2010), ADAMS Accession No. ML101320360.
[6] U.S. GAO Report to Congressional Requesters, GAO-11-563, Oversight of Underground Piping Systems Commensurate with Risk, but Proactive Measures Could Help Address Future Leaks (June 2011), *available at*, http://www.gao.gov/assets/320/319322.pdf (hereinafter "June 2011 GAO Report").
[7] Riverkeeper Comments on the Nuclear Regulatory Commission's Waste Confidence Decision Update and Proposed Rule regarding the Consideration of Environmental Impacts of Temporary Storage of Spent Fuel After Cessation of Reactor Operation (February 6, 2009), ADAMS Accession No. ML090410728.
[8] Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in the License Renewal Proceedings for the Indian Point Nuclear Power Plant (November 30, 2007), at 54-74, ADAMS Accession No. ML073410093.
[9] *See id.* at Contention EC-2 Exhibits (Gordon R. Thompson, *Risk-Related Impacts from Continued Operation of The Indian Point Nuclear Power Plants* (November 28, 2007); Edwin S. Lyman, *A Critique of the Radiological Consequence Assessment Conducted in Support of the Indian Point Severe Accident Mitigation Alternatives Analysis* (November 2007); Edwin S. Lyman, *Chernobyl on the Hudson? The Health and Economic Consequences of a Terrorist Attack at the Indian Point Nuclear Plant* (September 2004)).

of on-site nuclear waste storage during post-operations timeframes in light of the Federal Circuit Court's vacature of the NRC's Waste Confidence Decision.[10]

As a long-time advocate on environmental and safety issues associated with the ever-increasing inventories of spent fuel at Indian Point, I have extensive experience with the relevant issues.

Lastly, I note that as an environmental advocacy organization, Riverkeeper has been and will continue to be an active public stakeholder in NEPA-related processes, including commenting on the appropriate scope of environmental reviews, as well as environmental impact statements.

3. In *New York v. NRC*, 681 F.3d 471, 481 (D.C. Cir. 2012), the court concluded, among other things, that the Commission's analysis of SFP leaks in the stricken Waste Confidence Decision was insufficient. The Court chastised the Commission for relying only on statements about health impacts of past SFP leaks. In particular, the Court explained that (1) such impacts are not the only type that must be assessed, and (2) that a "proper analysis of the risks would necessarily look *forward* to examine the effects of the additional time in storage, as well as examining past leaks."[11] The Court further instructed that NRC cannot rely on existing recommendations for improvements to SFPs that NRC may have addressed or will address at some point; the Court emphasized that an existing monitoring or regulatory compliance program is not sufficient to demonstrate that significant environmental impacts will not occur during extended on-site pool storage period.[12]

In light of these directives, my declaration will address the proper scope of the proposed waste confidence environmental impact statement (the "EIS") as it relates only to assessing impacts of spent fuel pool ("SFP") leaks occurring after the expiration of a plant's operating license. Specifically, my declaration will explain that the EIS must analyze, in depth: (1) the probability of future leaks from SFPs; (2) the consequences of future leaks from SFPs; (3) the cumulative impacts of future leaks from SFPs and non-SFP systems, structures, and components; (4) measures that may mitigate the impacts of SFP leaks; and (5) the impact of decommissioning on SFP leaks.

EIS Must Analyze the *Probability* of Future Leaks from Spent Fuel Pools

4. The NRC's EIS must analyze in-depth the probability that densely packed SFPs at reactor sites will leak toxic radionuclides to the environment following the cessation of plant operations.

a. *Even before plants' operating licenses have expired, SPF leaks have occurred across the country.*

In light of evidence of already leaking SFPs around the country, which calls into question the current and future integrity of aging SFP structures at nuclear power plants, the NRC must

[10] State of New York, Riverkeeper, Inc., and Hudson River Sloop Clearwater's Joint Contention NYS-39/RK-EC-9/CW-EC-10 Concerning the On-Site Storage of Nuclear Waste at Indian Point (July 8, 2012), ADAMS Accession No. ML12190A002.
[11] *New York v. NRC*, 681 F.3d 471, 481 (D.C. Cir. 2012) (emphasis in original).
[12] *Id.*

conduct an in-depth and site-specific analysis in its EIS of SFP leaks to discern the extent and degree to which SFPs will leak in the future. Indeed, the NRC's previous assertion that "pool storage is a benign environment . . . that does not lead to significant degradation" and that "degradation mechanisms are well understood,"[13] has been called into question by occurrences at multiple sites where SFP structures have leaked (and in some cases, continue to leak) radioactive water into the subsurface.

For example, operators of Indian Point Entergy Center,[14] Brookhaven National Laboratories, Seabrook Station, Point Beach Nuclear Plant, and Salem Nuclear Generating Station have discovered radioactive leaks from SFPs or associated structures.[15] SFPs leaks occurring during the reactors' *initial* licensing terms raise a significant concern that the structural integrity of the SFPs may be compromised in timeframes much shorter than those contemplated in the scenarios proposed for the EIS. Indeed, NRC has implied that improved maintenance of SFPs is needed, notwithstanding the possibility of long-term onsite waste storage.[16] Notably, SFPs located at the existing fleet of U.S. nuclear power plants that have been in use for upwards of, or over, 40 years[17] face a typical "bathtub curve,"[18] i.e., ever-increasing aging issues and a stronger potential for leaks as they continue to operate. The instances of SFP leakage and related reactor operating experience indicate that future leaks of radioactive water from SFPs at currently operating reactors across the country are reasonably likely to occur during the "temporary" storage time period following permanent cessation of operations.

b. *The EIS must analyze in-depth the probability of future SFP leaks in light of the established practices that challenge and prevent full and timely detection of such leaks.*

The need for a detailed analysis of the probability of future SFP leaks is underscored by the marked inability of plant licensees to fully detect current, let alone future, SFP degradation and SFP leaks. The NRC has acknowledged and explained that "[s]ystems or structures can experience undetected radioactive leaks over a prolonged period of time" and that "[s]ystems or structures that are buried or that are in contact with soil, such as SFPs . . . are particularly susceptible to *undetected* leakage."[19] One particular challenge facing SFPs is that the high

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[13] *See, e.g.*, Waste Confidence Decision Update, NRC–2008–0482, 75 Fed. Reg. 81037, 81069 (Dec. 23, 2010).

[14] Radioactive water leaks from the Indian Point Unit 2 SFP remain active and will continue to occur into the indefinite future. For a full explanation of the past and ongoing problem of Indian Point Unit 2 SFP leaks, see Riverkeeper Statement of Position Regarding SFP Leaks Contention, *supra* Note 1.

[15] *See* Liquid Radioactive Release Lessons Learned Task Force Final Report, September 1, 2006, at 3-10, *available at*, ADAMS Accession No. ML062650312 (hereinafter "NRC 2006 Radioactive Release Lessons Learned Report").

[16] *Id.* at 26.

[17] The current fleet of U.S. nuclear reactors began operating decades ago and the majority of reactors have already received extended operating licenses and have, thus, been operating for over 40 years now; most of the remaining reactors are approaching the end of their initial 40 year operating licenses and are currently seeking or will soon seek extended operating licenses. *See generally* http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html (last visited December 13, 2012).

[18] A "bathtub curve" is defined as "the phenomenon that the fraction of products failing in a given timespan is usually high early in the lifecycle, low in the middle, and rising strongly towards the end. When plotted as a curve, this looks like the profile of a bathtub." WordIQ.com, Bathtub curve – Definition, http://www.wordiq.com/definition/Bathtub_curve (last visited Dec. 13, 2012).

[19] *See* NRC 2006 Radioactive Release Lessons Learned Report at 26, *supra* Note 15 (emphasis added).

density of spent nuclear fuel they contain has made it impossible to conduct complete physical inspections of the pools that would detect ongoing leaks and degraded conditions that could lead to future leaks. For example, at Indian Point, approximately 40% of the Indian Point 2 SFP liner, which has a history of leakage, has never been inspected as a result of the densely packed spent fuel that makes large portions of the pool inaccessible for inspection; the plant owner has no plans to complete any comprehensive inspections of the degraded SFP liner.[20] Indeed, it is unlikely that nuclear power plant licensees with sites that have a history of SFP leakage, let alone those with currently non-leaking SFPs, will voluntarily undertake periodic SFP inspections, or other proactive, preventative measures to timely avoid or stop future SFP leaks, in the absence of regulatory requirements that would mandate such inspections and a process for safely moving spent fuel in order to conduct them.

In addition, existing "tell tale" leak detection systems at some SFPs are not designed to detect slow, long term leaks that could result in extensive environmental contamination over time. In fact, the Indian Point 2 SFP was not built with a leak detection system at all.[21]

Such circumstances are exacerbated by the fact that, as NRC has explained, "SFP performance deficiencies are not specifically addressed in the NRC inspection program significance determination process."[22] Moreover, NRC has allowed nuclear power plant operators to rely upon a *voluntary* initiative to address accidental radiological leaks, which relies entirely upon voluntary monitoring of groundwater in order to detect radiological leaks from SFPs, as well as all other plant systems, structures, or components.[23] NRC's ongoing refusal to incorporate *mandatory* groundwater testing requirements into its regulations[24] is problematic and increases the likelihood that radiological SFP leaks may occur undetected. In any event, sole reliance on after-the-fact groundwater monitoring all-but ensures that some SFP leaks that do occur will not be discovered until after radioactive water has leached into the environment, groundwater, or surface waters.[25] Based on the foregoing, it is, and will continue to be, difficult for licensees to predict and detect degradation of SFPs and future radiological leaks that occur as a result of such

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[20] *See* Riverkeeper Statement of Position Regarding SFP Leaks Contention, *supra* Note 1; U.S. Nuclear Regulatory Commission, Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286 (November 2009), at 3-134, 3-139, *accessible at*, http://www.nrc.gov/reading-rm/adams/web-based.html, NRC ADAMS Accession No. ML093170671.

[21] Entergy, Problem Development Sheet – Groundwater (NRC Official Hearing Exhibit, Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), ASLBP #: 07-858-03-LR-BD01, Docket #: 05000247, 05000286, Exhibit # RIV000074-00-BD01), *available at*, ADAMS Accession No. ML12335A601.

[22] NRC 2006 Radioactive Release Lessons Learned Report at 26, *supra* Note 15; *see* also *Regulatory Roulette: The NRC's Inconsistent Oversight of Radioactive Releases from Nuclear Power Plants,* Dave Lochbaum, Union of Concerned Scientists, September 2010, available at http://www.ucsusa.org/assets/documents/nuclear_power/nuclear-power-radioactive-releases.pdf (last accessed December 21, 2012).

[23] *See* SECY-11-0019, Policy Issue, Senior Management Review of Overall Regulatory Approach to Groundwater Protection, (February 9, 2011), *available at*, http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2011/2011-0019scy.pdf, at 3-4 (hereinafter "SECY-11-0019").

[24] *See* NRC 2006 Radioactive Release Lessons Learned Report at iii, 33, *supra* Note 15; SECY-11-0019 at 3, *supra* Note 23.

[25] For example, evidence gleaned in the context of the Indian Point license renewal proceeding reveals numerous instances of radiological leaks that were detected by an "established" groundwater monitoring system months or years after initial radiological leakage began, and demonstrates the inadequacy of such monitoring. *See, e.g.*, Riverkeeper Statement of Position Regarding SFP Leaks Contention at 34, 36, *supra* Note 1.

degradation. The difficulties present in detecting SFP leaks makes a comprehensive assessment of the likelihood of such future leaks critically important: the EIS must fully analyze the probability of future SFP leaks in light of the established lack of regulatory requirements and industry practices that make full and timely detection of such leaks extremely unlikely. Given the regulatory history, this lack of requirements will ostensibly continue during the time period following permanent cessation of operations.

c. *The EIS must analyze in-depth and consider the likelihood of SPF leaks and releases resulting from human error.*

In addition to SFP leaks resulting from pool degradation and unforeseen structural problems, consideration of the extent to which SFPs will leak in the future must also fully take into account the likelihood of leaks and releases resulting from human error in operations relating to on-site nuclear waste. Numerous such radiological releases have already occurred.[26] Such instances have involved plant personnel not properly following procedures, not adequately monitoring, and not properly operating plant equipment.[27] Increased on-site storage of spent fuel in pools for many years after the expiration of the plant's licenses[28] patently increases the opportunity for human error resulting in unauthorized releases from SFPs. Such circumstances must be appropriately and adequately accounted for in the context of determining the probability of future SFP leaks.

d. *In analyzing SPF leaks, the EIS must take into account site-specific factors.*

Notably, determining the probability of future SFP leaks necessitates a consideration of site-specific factors. To begin with, special consideration must be afforded to SFPs that have already leaked. With respect to any known incidents of SFP leakage, the circumstances surrounding such leakage, the licensee and NRC response to such leakage, the adequacy of any such response, the current and likely future status of such leakage, and other such issues must be analyzed before determining the likelihood of future leakage from these SFPs. For example, at Indian Point, the history of SFP leakage, (including the facts that the Unit 2 SFP is still actively leaking), makes it reasonably likely that the Unit 2 SFP will continue to leak in the future.

In addition, other site-specific factors must be considered in order to assess the probability of future SFP leaks at nuclear power plants. These include the impact of natural disasters (i.e., earthquakes, hurricanes, floods, etc.) on the integrity of SFPs, and the probability that any such events may create or exacerbate existing SFP degradation and leaks. Such impacts must take into account current information regarding seismicity in regions where nuclear power plants are located,[29] as well as the most current scientific knowledge regarding sea level rise and other

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[26] NRC 2006 Radioactive Release Lessons Learned Report at 34, *supra* Note 15.
[27] *Id.*
[28] For the appropriate time frame NRC should use in evaluating the impacts of long-term onsite storage of spent nuclear fuel, *see generally*, Makhijani Declaration at Sections 3 and 4 and Thompson Declaration at Sections V and VI.
[29] In 2007, the NRC began examining new earthquake hazard information and found that various seismic hazard estimates have increased and required further analysis; NRC is currently continuing to update earthquake risk hazard estimates for U.S. nuclear power plants in light of newer information and seismic models. *See* Generic Issue 199 (GI-199), Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on

impacts of climate change, including the increased frequency of severe weather events that result in storm surges, flooding, and extended power outages that could compromise safe storage of spent fuel at reactor sites.[30] Site-specific review related to these kinds of external circumstances is necessary since new information reveals such issues can be problematic and since different regions in the U.S. face different geological conditions and weather patterns.[31]

e. *Conclusion: NRC must undertake a comprehensive, in-depth assessment, with due consideration of site-specific factors, of the probability of SFP leaks during post-operation on-site storage of spent nuclear fuel.*

In sum, NRC must undertake a comprehensive assessment, with due consideration of site-specific factors, of the probability of SFP leaks during post-operation on-site storage of spent nuclear fuel.[32] In accordance with the Court of Appeal's decision, NRC must speak fully to "whether and how future leaks might occur."[33] NRC cannot simply rely on the findings or outcomes of its groundwater task force initiative relating to alleged "improvements" to SFPs or otherwise. For example, a monitoring and regulatory compliance program is *not* "a buffer against pool degradation," and NRC cannot conclude that "leaks will not occur because the NRC is 'on duty.'"[34] Any alleged assurances from NRC regarding the low likelihood of future SFP leaks or assurances that the eventuality of such leaks is "under control," are not substitutes for the full analysis that is required, as detailed above.

Existing Plants: Safety/Risk Assessments, August 2010, ADAMS Accession No. ML100270639; Memo from P. Hiland to B. Sheron Re: Results of Safety/Risk Assessment of Generic Issue 199, September 2, 2010, ADAMS Accession No. ML100270598. Site-specific consideration of such new information and analyses concerning regional seismology and hazards posed therefrom is necessary for determining risks of future SFP leaks at particular nuclear power plants. For example, a study by Columbia University seismologists in 2008 concluded that the area surrounding the Indian Point nuclear plant was not, as previously thought, an area of low seismic activity, and that, in fact, it was "quite possible" the region could experience upwards of a 7.0 magnitude earthquake, which the owner of the plant has admitted Indian Point is not designed to withstand. *See* Lynn R. Sykes, John G. Armbruster, Won-Young Kim, & Leonardo Seeber, Observations and Tectonic Setting of Historic and Instrumentally Located Earthquakes in the Greater New York City--Philadelphia Area, Bulletin of the Seismological Society of America, Vol. 98, No. 4, pp. 1696–1719, August 2008; The Earth Institute, Columbia University, "Earthquakes May Endanger New York More than Thought, Says Study: Indian Point Nuclear Power Plant Seen as Particular Risk," Press Release Posted on The Earth Institute website, August 21, 2008, *available at*, http://www.earth.columbia.edu/articles/view/2235 (last visited December 13, 2012). Any such new information must be considered in relation to the risk of future SFP leaks at particular plants as waste is stored in such pools during post-operation timeframes.

[30] *See, e.g.*, NRC Event Notification Report #48452 for Oyster Creek (October 29, 2012), *available at*, http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2012/20121030en.html (Notice of unusual event declared due to high intake structure water level).

[31] For additional information regarding the necessity of site-specific review, *see*, Makhijani Declaration at Section 9.

[32] For the appropriate time frame NRC should use in evaluating the impacts of long-term onsite storage of spent nuclear fuel, *see generally*, Makhijani Declaration at Sections 3 and 4 and Thompson Declaration at Sections V and VI.

[33] *New York v. NRC*, 681 F.3d 471, 481 (D.C. Cir. 2012).

[34] *Id.*