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OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT	)	Docket No. 50-400 - LA
(Shearon Harris Nuclear	)	ASLBP No. 99-762-02-LA
Power Plant)	)	
	)	

ORANGE COUNTY'S REQUEST FOR EMERGENCY STAY OF LBP-01-09

I. INTRODUCTION AND SUMMARY

Pursuant to 10 C.F.R. § 2.788, the Board of Commissioners of Orange County, North Carolina ("Orange County") hereby moves the Nuclear Regulatory Commission ("NRC" or "Commission") for a stay of LBP-01-09, the Licensing Board's Memorandum and Order (Denying Request for Evidentiary Hearing and Terminating Proceeding) (March 1, 2001). LBP-01-09 terminates this contested license amendment proceeding and approves the issuance of a license amendment to Carolina Power & Light ("CP&L") for the substantial expansion of spent fuel capacity at the Harris nuclear plant.

This stay motion is supported by the attached declaration of Dr. Gordon Thompson.[1] Dr. Thompson's Declaration demonstrates that the proposed license amendment would cause imminent irreparable injury by significantly increasing the consequences of a severe spent fuel pool accident.[2]

1 Declaration of 16 March 2001 by Dr. Gordon Thompson in Support of Orange County's Stay Motion of 16 March 2001 (March 16, 2001) ("Thompson 16 March 2001 Declaration").

2 Orange County is concerned that the harm which it seeks to avoid through the filing of this stay motion is imminent. Modifications to pools C and D are now ongoing. In addition, CP&L has said that it will begin moving fuel into the pools in June. Therefore, the County requests that the Commission give this motion expedited consideration. If the County has not received a decision on this motion by April 16, 2001, the County will be forced to treat the Commission's silence as a denial of the motion, for purposes of determining whether to seek further relief from the U.S. Court of Appeals.

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II. FACTUAL AND PROCEDURAL BACKGROUND

In this contested license amendment proceeding, Carolina Power & Light Company ("CP&L"), seeks to activate two spent fuel pools (labeled "C" and "D") for which it abandoned its construction permit application and quality assurance program in the early 1980's. Pools A and B now have a combined capacity of 1,128 PWR spent fuel assemblies and 2,541 BWR assemblies. The proposed license amendment would allow CP&L to use pools C and D for storage of an additional 1,952 PWR spent fuel assemblies and 2,763 BWR assemblies. This would bring the amount of fuel to be stored at Harris to 8,343 assemblies, over a thousand more assemblies than were assumed in the 1983 FEIS.

This stay motion concerns the Licensing Board's disposition of contested issues in the Harris license amendment proceeding, in LBP-00-12 and LBP-01-09. In LBP-00-12, the Board ruled that Orange County's evidentiary and legal presentations under 10 C.F.R. Part 2 Subpart K, regarding criticality prevention and quality control issues, were insufficient to demonstrate the need for a hearing. 51 NRC 247 (2000). The Board's decision included the ruling that General Design Criterion 62 of 10 C.F.R. Part 50 permits reliance on administrative and procedural criticality prevention measures such as enrichment/burnup control.[3]

In LBP-01-09, the Licensing Board decided not to conduct a full evidentiary hearing on Orange County's environmental Contention, EC-6, and terminated the license amendment proceeding. The Board had admitted Contention EC-6 in LBP-00-19, 52

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3 *Id.* On May 22, 2000, Orange County filed a petition for review of LBP-00-12. The petition was denied without prejudice, on grounds of prematurity. *See* CLI-00-11, 51 NRC 297 (2000). Later, Orange County was given the opportunity to participate as an amicus on appeal of LBP-00-26, a decision interpreting criticality prevention requirements in a spent fuel pool expansion case involving the Millstone nuclear power plant. *See Northeast Nuclear Energy Company* (Millstone Nuclear Power Station, Unit 3),

NRC 85 (2000). Contention EC-6 charged that the Environmental Assessment ("EA") prepared by the Staff was inadequate to justify the Staff's refusal to prepare an Environmental Impact statement ("EIS"), because it failed to take into consideration new information and changed circumstances, showing the foreseeable potential for a severe spent fuel pool accident following a degraded core accident with containment failure or bypass.

In admitting Contention EC-6, the Board found that Orange County had established "an adequate basis to allow merits litigation on whether the following accident sequence is not 'remote and speculative' so that a further environmental analysis of the CP&L pool expansion amendment is required," with respect to the following seven-step accident scenario:

> 1) a degraded core accident;
> 2) containment failure or bypass;
> 3) loss of all spent fuel cooling and makeup systems;
> 4) extreme radiation doses precluding personnel access;
> 5) inability to restart any pool cooling or makeup systems due to extreme radiation doses;
> 6) loss of most or all pool water through evaporation; and
> 7) initiation of an exothermic oxidation reaction in pools C and D.

52 NRC at 95. Following discovery, the Board invoked the summary procedures of Subpart K to 10 C.F.R. Part 2, and required the parties to file written presentations and deliver oral argument to determine whether the hearing should go forward.

In support of its position, Orange County filed an extensive legal brief and detailed expert report by Dr. Gordon Thompson.[4] Dr. Thompson's report relied to a

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CLI-01-03 (January 17, 2001). Orange County filed an amicus brief on February 7, 2001.

4 *See* Detailed Summary of Facts, Data, and Arguments and Sworn Submission on which Orange County Intends to Rely at Oral Argument to Demonstrate the Existence of a Genuine and Substantial Dispute with the Licensee Regarding the Proposed Expansion of Spent Fuel Storage Capacity at the Harris Nuclear Power Plant with Respect to the Need to Prepare an Environmental Impact Statement to Address the Increased Risk of a Spent Fuel Pool Accident (November 20, 2000) ("Orange County's Summary re:

significant extent on information and analyses previously prepared by CP&L and the NRC Staff. His report presented substantial and material evidence that the probability of an exothermic reaction in the spent fuel pools, leading to a massive release of radiation from the pools, is foreseeable, and may not be disregarded as a remote and speculative event. Orange County's legal brief also showed that the NRC Staff unlawfully relied on assumptions regarding doses to workers during accidents that are inconsistent with the requirements of the National Environmental Policy Act ("NEPA").[5]

The NRC Staff and CP&L also filed legal and evidentiary presentations, arguing that the probability of a severe spent fuel pool accident is too small to warrant consideration. Although there were some areas of agreement between the parties, their analyses showed stark differences in the information relied on, analytical approach, and results reached. At the oral argument on December 7, 2000, Orange County pointed out that CP&L's and the Staff's technical analyses contained considerable omissions and deficiencies, including failure to provide transparent technical analysis or actual calculations regarding some parameters, and oversimplification of accident behavior.

On March 1, 2001, the Licensing Board issued LBP-01-09, which denied Orange County a full evidentiary hearing on Contention EC-6 and terminated the proceeding.[6]

Contention EC-6"); BCOC Exhibit 1, Declaration of Dr. Gordon Thompson (November 20, 2000) ("Thompson Declaration"); BCOC Exhibit 2, G. Thompson, *The Potential for a Large, Atmospheric Release of Radioactive Material From Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release initiated by a Severe Reactor Accident* (November 20, 2000) ("Thompson Report"). These documents were previously provided to the NRC Commissioners as attachments to Orange County's Petition for Review and Request for Immediate Suspension and Stay of the NRC Staff's No Significant Hazards Determination and Issuance of License Amendment for Harris Spent Fuel Pool Expansion (December 22, 2000).

5 *See* Orange County's Summary re: Contention EC-6 at 31-38.

6 The decision went through each of the seven accident steps the parties had been asked to address, and compared the evidence presented by the three parties. For each of the seven steps, the Board ruled that Orange County had not met the NRC's standard for proceeding to an evidentiary hearing. The Board accepted the NRC Staff's calculation that the probability of the seven-step accident is "conservatively in the range of" 2.0E-7 per reactor year, and found that this level of probability falls within the realm of "remote

III. ORANGE COUNTY SATISFIES THE COMMISSION'S REQUIREMENTS FOR ISSUING A STAY.

A balancing of the four factors set fourth in 10 C.F.R. § 2.788(e) shows that Orange County meets the standard for the granting of a stay.

A. Orange County Has a Strong Likelihood of Prevailing on the Merits.

In a petition for review filed today, Orange County seeks Commission review of a number of rulings by the Licensing Board regarding criticality prevention, quality assurance, and environmental issues.[7] The County believes that issuance of a stay is favored by Orange County's high probability of success on all of these challenges. Given the space constraints of this motion, however, it is only possible to address a selection of these issues.

1. LBP-01-09. Orange County has a high probability of success in gaining the reversal of LBP-01-09. In LBP-01-09, the Licensing Board committed both legal error and clear factual error, in three major respects. First, the Board misapplied the standard used in Subpart K proceedings for determining whether to order a hearing. Under 10 C.F.R. § 2.1115, the Board was required to review written evidentiary and legal presentations and conduct an oral argument to determine whether there is a genuine and substantial dispute of material fact between the parties, that can only be resolved in a hearing. The purpose of the proceeding is to separate "genuine factual issues (for subsequent adjudication) from issues of policy or law and/or frivolous factual issues."[8] Although the intervenor bears the burden of showing a genuine and substantial material issue of fact that should go to a hearing, the license amendment applicant bears the

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and speculative" events not cognizable under NEPA. LBP-01-09, slip op. at 34-36.

7 See Orange County's Petition for Review of LBP-00-12, LBP-00-19, and LBP-01-09.

8 Proposed Rule, Hybrid Hearing Procedures for Expansion of Onsite Spent Fuel Storage Capacity at

ultimate burden of proof, and the Staff also bears the burden of proof on NEPA issues. LBP-01-09, slip op. at 10-12. The Commission has likened the Subpart K process to summary disposition.[9]

Here, the Licensing Board went far beyond the bounds of determining whether there is a genuine and substantial dispute of material fact. Instead, the Board entered the merits of the dispute, weighed the credibility of each side in the dispute, and chose for one of the parties.[10] The Board had no basis for making this choice, other than its own predilections. Resolution of disputed factual issues must be reserved for trial, after hearing testimony from the experts.[11] Orange County met its burden of demonstrating a genuine and substantial dispute of material fact that could only be resolved at a full evidentiary hearing. By reaching the merits of the dispute, the Licensing Board illegally shifted the ultimate burden of proof from CP&L and the NRC Staff to Orange County.

Second, even if it were appropriate for the Board to go to the merits of the dispute, the Board's ruling was based on an arbitrary and capricious selection of facts favorable to the NRC Staff.[12] In all areas where there was a dispute between the parties as to the best probability estimate for a given step in the seven-step scenario, the Licensing Board

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Civilian Nuclear Power Plants, 48 Fed. Reg. 54,499, 54,451 (December 5, 1983).

9 Final Rule, Hybrid Hearing Procedures for Expansion of Onsite Spent Fuel Storage Capacity at Civilian Nuclear Power Plants, 50 Fed. Reg. 41,662, 41,669 (October 15, 1985).

10 For example, the Board consistently uses terminology reflecting a weighing of the evidence, rather than the identification of genuine and substantial issues of fact. Its determinations are based on the basis of the comparative credibility (pages 21, 26, 31); reasonableness (pages 23, 26, 33), and persuasiveness (page 23) of the parties positions. The Board also makes judgments about the comparative complexity of the parties' analyses. *Id.*, slip op. at 26.

11 *Sequoyah Fuels Corp. and General Atomics* (Gore, Oklahoma Site Decontamination and Decommissioning Funding), LBP-94-17, 39 NRC 359, 361 (1994).

12 The Board makes a point of not relying on CP&L's analysis. *See* LBP-01-09, slip op. at 16-17. However, throughout the decision, it summarizes CP&L's analysis uncritically, thus giving the strong impression that CP&L's analysis would constitute independent and additional grounds to rule against a hearing. This message has no basis in fact. As discussed during oral argument, CP&L's analysis is fatally defective because it omits critical data and calculations that are necessary in order to make a reasonable evaluation of the reliability of its conclusions. *See* Transcript of December 7, 2000, oral argument at 468-76, 483-83, 596, 493-95.

ignored or summarily rejected Orange County's factual evidence, without providing a reasoned explanation.[13] This lack of accountability flagrantly violates NRC precedent.[14]

Finally, the Board based its decision on a critical assumption that is inconsistent with NEPA. In order to come up with a very low probability calculation for a spent fuel pool fire, the NRC Staff assumed the workers would incur doses above regulatory limits in order to stop the accident from progressing to that point.[15] *See* LBP-01-09, slip op. at

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13 For example, the Board completely ignores Orange County's evidence regarding the type of analysis needed to make a credible probability estimate for a spent fuel pool fire. *See* Thompson 2000 Report, Section 3. The Board also misrepresents Orange County's position on the potential occurrence of a degraded-core accident at Harris. At pages 17-19, the Board misrepresents the County's estimate of the overall probability of four *selected* sequences as the County's estimate of the probability of core degradation through *all possible* sequences. The Board also misrepresents Orange County's position about the loss of spent fuel pool cooling that accompanies the four selected sequences. In discussing these sequences, the ASLB states that all of them "lead finally to a loss of cooling to the fuel pools." To the contrary, each sequence involves a loss of cooling to the fuel pools from the beginning of the accident sequence until the occurrence of core degradation and potentially beyond. This point is significant because it bears upon the potential for recover of pool cooling, and thereby on the probability of a pool fire.

At pages 19-21, the ASLB shows a complete misunderstanding of Orange County's position regarding the potential for a degraded-core accident to lead to containment bypass. The Board characterizes Orange County's analysis as "too simplistic," but fails to address the fact that Orange County drew its analysis from an NRC Staff analysis. It also fails to address the fact that the NRC Staff did not address the significance of its own analysis in its evidentiary presentation. In footnote 5, the Board again shows a poor understanding of the literature regarding the effect of high levels of fuel burnup on the release of radioactive material from a reactor to the atmosphere during a degraded-core accident. The Board ignored a relevant study, NUREG-1465, and misinterpreted a research paper on the subject. As a result, the Board arbitrarily resolved a genuine and substantial factual dispute between the parties based on its own arbitrary and ill-informed weighing of the merits of the evidence.

At pages 26-27, the Licensing Board credited the NRC Staff's analysis of deposition patterns of radioactive material onsite, partly on the ground that Orange County had not itself modeled the deposition patterns. The Board completely disregarded Orange County's criticisms of the method used by the NRC Staff to estimate onsite radiation levels. Instead, it shifted to Orange County the burden of proving that radiation levels would be higher than calculated by the Staff. These are but some examples of the many factual errors made by the Licensing Board. It would be impossible, given the page limitations of this motion, to list them all. These examples illustrate the extreme arbitrariness of the Licensing Board's handling of a complex and fact-intensive dispute between the parties to this proceeding.

14 *See Public Service Electric and Gas Company, Atlantic City Electric Company* (Hope Creek Generating Station, Units 1 and 2), ALAB-429, 6 NRC 229, 237 (1977) ("a Licensing Board must do more than reach conclusions; it must 'confront the facts.'"") (citation omitted). As in *Hope Creek*, this record "is devoid of any systematic analysis by expert witnesses for either the applicant or the staff of the differences between [two studies at issue in the hearing]." *Id.* Instead, without the benefit of the substantial expertise required to evaluate the issues at hand, the Board makes its own arbitrary judgments on the merits of the case.

15 A dose of 5 rems TEDE per year per year is the occupational dose limit established by NRC standards for protection of worker safety and health. *See* 10 C.F.R. § 20.1201(a)(1)(i). The NRC Staff assumes that workers will incur a dose of 25 rems in an accident at Harris. The issue here is not whether workers would

28-30. In approving a probability calculation that is based on this assumption, the Licensing Board unlawfully accepted one type of environmental harm (radiation exposure to plant workers beyond regulatory limits) as the justification for avoiding another type of environmental harm (harm to the general public and the environment caused by radiological releases from the spent fuel pools), without going through the process of fully disclosing these competing harms in an EIS.[16]

2. LBP-00-12. Orange County also has a high probability of success in reversing the Board's decision regarding the interpretation of GDC 62.[17] The Licensing Board ruled that administrative and procedural controls such as enrichment/burnup controls constitute acceptable criticality prevention measures under GDC 62. This extremely broad reading of GDC 62 is inconsistent with the plain language of the regulations and their regulatory history.[18] The language of GDC 62 which restricts criticality prevention measures to "physical systems and processes" must necessarily be read to exclude non-physical systems and processes, such as administrative and procedural controls. It is also significant that in the rulemaking for GDC 62, the Commission dropped the phrase "procedural controls" from a phrase describing acceptable criticality prevention measures. The Licensing Board's decision is inconsistent with the plain language and regulatory history of GDC 62 because it would allow *any* form of criticality prevention measures, thus defeating the purpose of the rule's

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be willing to incur such doses during a real accident, but whether such high doses can be assumed *for purposes of avoiding the preparation of an EIS.*

16 *See also* Orange County's Summary re: Contention EC-6 at 31-38.

17 GDC 62 requires that "Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations."

18 Orange County discusses the language and regulatory history of GDC 62 at length in its Detailed Summary ... With Respect to Criticality Prevention at 18-40 (January 4, 2000). The issue is also addressed in the briefs on appeal of LBP-00-26 which were filed in the Millstone license amendment proceeding by the Connecticut Coalition Against Millstone and Long Island Coalition Against Millstone on February 7

limiting language.

B. Orange County Will Suffer Immediate and Irreparable Harm.

In LBP-01-09, the Licensing Board found that the likelihood of a spent fuel pool accident at Harris is in the realm of "remote and speculative." However, as discussed above, the Licensing Board's decision is fatally defective in significant respects. Because of the many errors made by the Licensing Board in LBP-01-09, it significantly understates the potential for a severe accident in the Harris spent fuel pools.[19]

In any event, as the U.S. Court of Appeals has recognized, even where the likelihood of an accident is small, a stay may be warranted where "the potential severity is enormous" and "the injuries which could result are indisputably irreparable." *State of Ohio ex rel. Celebrezze v. NRC,* 812 F.2d 288, 291 (6th Cir. 1987). As discussed in Dr. Thompson's Declaration, the consequences of a severe accident in the spent fuel pools at Harris would be catastrophic, amounting to a "national disaster of historic proportions." Thompson 16 March 2001 Declaration, par. 43.

In addition, if CP&L is allowed to continue making the repairs and other modifications to the cooling systems for pools C and D that are now authorized by LBP-01-09, they may jeopardize fair consideration of alternatives in any EIS that the NRC Staff is later required to prepared. While these modifications do not involve any change in the radioactive inventory of the plant, they do involve the irretrievable commitment of resources to the expansion of the spent fuel cooling system, before alternatives have been considered.[20] Accordingly, to permit these modifications to go forward would violate the

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and March 15, 2001; and Orange County's Amicus Brief in that proceeding, also filed on February 7, 2001.

19 The errors by the Licensing Board which result in the underestimation of accident probability are discussed throughout the Thompson 16 March 2001 Declaration.

20 If an EIS ultimately is required for the Harris license amendment, these expenditures may well be

cardinal principle of NEPA that prejudice to environmental decisionmaking must be avoided by preparing an EIS *before* taking a proposed major federal action significantly affecting the human environment. *Robertson v. Methow Valley Citizen Council*, 490 U.S. 332, 349 (1989).

C. The Harm to Other Parties Is Minimal.

The harm to other parties caused by a stay is minimal, compared to the potential harm caused by an accident in the pools at Harris, and the harm caused by foreclosure of the consideration of viable alternatives under NEPA.

D. The Public Interest Favors Issuance of a Stay.

The issuance of a stay is in the public interest. Orange County, which has responsibility for the health and welfare of thousands of citizens, has intervened in the adjudication for the purpose of resolving its concerns about the safety and environmental impacts of the massive increase in the volume of spent fuel which CP&L proposes to store in high-density racks. It is fair and appropriate to protect the integrity of Orange County's appeal, and public confidence in the NRC's participatory decisionmaking process, by delaying the issuance of a license until the safety and NEPA issues that have been placed before the Commission have been resolved.

IV. CONCLUSION

For the foregoing reasons, the Commission should stay the effectiveness of LBP-01-09, pending its consideration of Orange County's Petition for Review of LBP-00-12, LBP-00-19, and LBP-01-09.

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considered to constitute sunk costs. In addition, if CP&L is permitted to incur transportation costs involved in bringing spent fuel from other reactors to store in high density racks in pools C and D, these expenditures may also be treated as sunk costs. *See, e.g., Public Service Company of New Hampshire* (Seabrook Station, Units 1 & 2), ALAB-422, 5 NRC 503, 532 (1977).

Respectfully submitted,

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NUCLEAR REGULATORY COMMISSION
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In the Matter of	)	
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CAROLINA POWER & LIGHT	)	Docket No. 50-400-LA
(Shearon Harris Nuclear	)	ASLBP No. 99-762-02-LA
Power Plant)	)	
	)	

DECLARATION OF 16 MARCH 2001
BY DR. GORDON THOMPSON IN SUPPORT OF
ORANGE COUNTY'S STAY MOTION OF 16 MARCH 2001

I, Gordon Thompson, declare as follows:

Introduction

(1) I am the executive director of the Institute for Resource and Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. Our office is located at 27 Ellsworth Avenue, Cambridge, MA 02139. IRSS was founded in 1984 to conduct technical and policy analysis and public education, with the objective of promoting peace and international security, efficient use of natural resources, and protection of the environment.

(2) I have been retained by the Board of Commissioners of Orange County, North Carolina, as an expert witness in a proceeding before the U.S. Nuclear Regulatory Commission (NRC), in which Carolina Power & Light Co. (CP&L) has applied for a license amendment to permit the significant expansion of spent fuel pool storage capacity at the Harris nuclear power plant.

(3) This declaration supports Orange County's motion to stay the effectiveness of a memorandum and order dated 1 March 2001 by the Atomic Safety and Licensing Board (ASLB) in the Harris license amendment proceeding.[1] Hereafter, I refer to that memorandum and order as "the ASLB Order". The purpose of my declaration is to support my opinion that the expansion of spent fuel pool storage capacity approved by the ASLB Order poses the threat of imminent irreparable harm to public health and the environment. I base my opinion on the analytical work that I have done in the course of this proceeding regarding the probability of a spent fuel pool accident at Harris. This work is

[1] ASLB, Memorandum and Order, LBP-01-09, Docket No. 50-400-LA, ASLBP No. 99-762-02-LA, 1 March 2001.

described in paragraph 14 below. Furthermore, I believe that the Licensing Board's conclusion that a severe spent fuel pool fire is extremely unlikely is based on misunderstandings and misrepresentations of my work, and also shows a fundamental misunderstanding of the phenomena associated with severe reactor accidents. Below, I will address these deficiencies in the ASLB Order. I will also address deficiencies in analyses by CP&L and the NRC Staff that are referred to in the ASLB Order.

My Qualifications

(4) I am an expert in the technical analysis of safety and environmental issues related to nuclear facilities. My Curriculum Vitae is provided here as Attachment A.

(5) I received an undergraduate education in science and mechanical engineering at the University of New South Wales, in Australia. Subsequently, I pursued graduate studies at Oxford University and received from that institution a Doctorate of Philosophy in mathematics in 1973, for analyses of plasmas undergoing thermonuclear fusion. During my graduate studies I was associated with the fusion research program of the UK Atomic Energy Authority. My undergraduate and graduate work provided me with a rigorous education in the methodologies and disciplines of science, mathematics, and engineering.

(6) Since 1977, a significant part of my work has consisted of technical analyses of safety and environmental issues related to nuclear facilities. These analyses have been sponsored by a variety of nongovernmental organizations and local, state and national governments, predominantly in North America and Western Europe. Drawing upon these analyses, I have provided expert testimony in legal and regulatory proceedings, and have served on committees advising US government agencies. To illustrate my expertise, I provide in the following paragraphs some details of my experience.

(7) I have conducted, directed, and/or participated in a number of studies that evaluated aspects of the design and operation of nuclear facilities with respect to severe accident probabilities and consequences. These include generic studies and studies of individual facilities. For instance, with respect to generic studies on the potential for severe accidents at nuclear power plants, I was co-investigator in a study by the Union of Concerned Scientists on the "source term" issue -- the potential for release of radioactive material from containment.[2] Also,

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[2] Steven Sholly and Gordon Thompson, The Source Term Debate (Cambridge, Massachusetts: Union of Concerned Scientists, January 1986).

I was one of a team of four scientists who prepared a comprehensive critique of the state of the art of probabilistic risk assessment (PRA) for Greenpeace International.[3] In addition, I conducted analysis on the relevance of PRA to emergency response planning, as part of a study on emergency planning for nuclear power plant accidents.[4] All of these studies required me to be highly familiar with the design and operation of nuclear power plants, as well as the characteristics of probabilistic risk assessment.

(8) I have also done considerable work on the risks posed by individual nuclear facilities. In addition to performing the studies described elsewhere in this declaration, I have studied the risks posed by the Seabrook plant (USA), the La Hague site (France), the Darlington station (Canada), the Sizewell B station (UK), the Dukovany plant (Czech Republic) and the Pickering station (Canada). All of these studies required me to become familiar with the relevant details of the design and operation of the facilities involved.

(9) To a significant degree, my work has been accepted or adopted by relevant governmental agencies. During the period 1978-1979, for example, I served on an international review group commissioned by the government of Lower Saxony (a state in Germany) to evaluate a proposal for a nuclear fuel cycle center at Gorleben. I led the subgroup that examined accident risks and alternative options with lower risk. One of the risk issues that I identified and analyzed was the potential for an exothermic reaction of fuel cladding in a high-density fuel pool if water is lost. I identified partial loss of water as a more severe condition than total loss of water. I identified and described alternative fuel storage options with lower risk. The Lower Saxony government accepted my findings and ruled that high-density pool storage was not an acceptable option at Gorleben. As a direct result, policy throughout Germany has been to use dry storage, rather than high-density pool storage, for away-from-reactor storage of spent fuel.

(10) My work has also influenced decisionmaking by safety officials in the U.S. Department of Energy (DOE). During the period 1986-1991, I was commissioned by environmental groups to assess the safety of the military production reactors at the Savannah River Site, and to identify and assess alternative options for the production of tritium for the US nuclear arsenal. Initially, much of the relevant information was classified or otherwise inaccessible to the public. Nevertheless, I

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[3] H Hirsch et al, IAEA Safety Targets and Probabilistic Risk Assessment (Hannover, Germany: Gesellschaft fur Okologische Forschung und Beratung mbH, August 1989).

[4] D Golding et al, Preparing for Nuclear Power Plant Accidents (Boulder, Colorado: Westview Press, 1995).

addressed safety issues through analyses that were recognized as accurate by nuclear safety officials at DOE. I eventually concluded that the Savannah River reactors could not meet the safety objectives set for them by DOE. DOE subsequently reached the same conclusion, and scrapped the reactors. The current national policy for tritium production is to employ commercial reactors, an option that I had concluded was technically attractive but problematic from the perspective of nuclear weapons proliferation.

(11) In 1977, and again during the period 1996-2000, I examined the safety of nuclear fuel reprocessing and liquid high-level waste management facilities at the Sellafield site in the UK. My investigation in the latter period was supported by consortia of local governments in Ireland and the UK, and my findings have been presented at briefings in the UK and Irish parliaments. I identified safety issues that were not addressed in any publicly available literature about the Sellafield site. As a direct result of my investigation, the UK Nuclear Installations Inspectorate (NII) has required the operator of the Sellafield site to conduct extensive safety analyses. These analyses have confirmed the significance of the safety issues that I identified, and the NII has recently (January 2001) established a binding schedule for reduction of the inventory of liquid high-level radioactive waste at Sellafield.

(12) As stated above (see paragraph 9), I determined in the period 1978-1979 that partial loss of water from a high-density spent fuel pool is a more severe condition than total loss of water. This is because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies. During any scenario for loss of water from a spent fuel pool, there will be a period of time during which residual water is present. As a result, comparatively old fuel -- potentially including fuel aged 10 or more years after discharge from a reactor -- can ignite if water is lost from a high-density spent fuel pool. During the Harris license amendment proceeding, the NRC Staff repeatedly disparaged my statements that comparatively old fuel can ignite. Eventually, however, the Staff adopted my position. In a report dated October 2000, but not published until January 2001, the Staff recognized that the flow of air to exposed fuel assemblies could be blocked by collapsed structures (as as result of a cask drop or an earthquake) or the presence of residual water.[5] The Staff analyzed the heat transfer implications of flow blockage and concluded:[6]

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[5] Timothy Collins et al (authors are all from the NRC Staff), Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, October 2000.

[6] Collins et al, 2000 (op cit), page 2-1.

> "While the February 2000 [draft] study indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, the revised analyses show that it is not feasible, without numerous constraints, to define a generic decay heat level (and therefore decay time) beyond which a zirconium fire is not physically possible."

(13) In the course of the Harris license amendment proceeding, I have gained considerable knowledge regarding the specific design features of the Harris plant, as well as its operation. Taken together with my general knowledge of nuclear power plant design and operation, this provides me with a more-than-adequate basis for applying principles of risk analysis to the Harris reactor. In addition, during the course of the Harris license amendment proceeding, I have updated and supplemented my already extensive knowledge regarding the general characteristics of potential reactor accidents and spent fuel pool accidents, and the analytic techniques that are available for investigation of the probability and consequences of such accidents.

(14) While serving as an expert witness in the Harris license amendment proceeding, I have been required to provide analyses, and to evaluate analyses by others, regarding the potential for a severe spent fuel pool accident at the Harris nuclear power plant. In performing these functions, I have been careful to confine my statements to matters that I am qualified, by training and knowledge, to address as an expert.

Spent Fuel Pool Fires

(15) The ASLB Order addresses the potential for a severe spent fuel pool accident at the Harris plant. More specifically, it addresses the potential for a self-propagating exothermic oxidation reaction in one or more of the Harris pools, in the event that water is lost from these pools. For simplicity, a self-propagating exothermic oxidation reaction of this kind is referred to hereafter as a "pool fire". In a pool fire, air or steam would react with the zirconium cladding of the spent fuel and, potentially, with other materials in the pool. Radioactive material would be released from the spent fuel to the interior of the fuel handling building and from there to the outside atmosphere; the material released to the atmosphere would then travel downwind in a plume and contaminate the offsite environment.

(16) As indicated in paragraph 9, I identified and analyzed the potential for a pool fire while advising the government of Lower Saxony in the period 1978-1979. The NRC Staff's first report on the potential for a pool fire -- NUREG/CR-0649, prepared by Sandia Laboratories -- was published after my work for Lower

Saxony was completed.[7] Subsequently, the NRC Staff and its consultants conducted a number of studies that addressed pool fires. In a report prepared for Orange County in February 1999, I reviewed NUREG/CR-0649 and subsequent NRC Staff studies.[8] I updated my review of NRC Staff studies in a 20 November 2000 report for Orange County.[9] On 20 November 2000, in the context of the Harris license amendment proceeding, the Staff proferred an analysis that addressed pool fires. Deficiencies in that analysis are addressed later in this declaration. In January 2001, the NRC published a Staff study dated October 2000, which addressed pool fires at decommissioning plants.[10] That study is described hereafter as "the Staff's October 2000 report". I discussed the Staff's October 2000 report in comments that were submitted to the NRC Commissioners by Orange County.[11] In the following paragraphs I make some general observations about the potential for pool fires, and about the Staff's understanding of pool fires. Those observations are based on the documents cited above.

(17) The potential for a pool fire arises because the NRC has allowed plant licensees to adopt high-density storage of spent fuel in pools. When the present generation of nuclear plants first entered service, spent fuel pools employed low-density, open-frame racks. If water were lost from such a pool, the fuel cladding would ignite, if at all, only in rare conditions. By contrast, if water is lost from a high-density pool, the fuel cladding will ignite in a wide range of conditions.

(18) High-density pool storage is used because it is a comparatively cheap option. Dry storage offers a proven alternative but is more expensive. Thus, the risk of a pool fire is almost completely avoidable. This risk exists because

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[7] A S Benjamin at al, Spent Fuel Heatup Following Loss of Water During Storage, NUREG/CR-0649, March 1979.

[8] Gordon Thompson, Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant (Cambridge, Massachusetts: Institute for Resource and Security Studies, February 1999).

[9] Gordon Thompson, The Potential for a Large, Atmospheric Release of Radioactive Material from Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release Initiated by a Severe Reactor Accident (Cambridge, Massachusetts: Institute for Resource and Security Studies, 20 November 2000).

[10] Collins et al, 2000 (op cit).

[11] Gordon Thompson, Comments on the NRC Staff's Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (Cambridge, Massachusetts: Institute for Resource and Security Studies, 19 February 2001).

licensees are unwilling to bear the cost of avoiding the risk, and because the NRC has allowed licensees to create the risk.

(19) The potential for a pool fire exists at operating plants as well as decommissioning plants. Indeed, the risk of a pool fire is greater at operating plants, for two reasons. First, operating plants always have a significant inventory of recently-discharged fuel which is more prone to ignition, given a loss of water, than older fuel.[12] Second, there are potential interactions between operating reactors and adjacent spent fuel pools, whereby an accident at the reactor could lead to a pool fire or vice versa.

(20) Beginning with NUREG/CR-0649 in 1979, the NRC Staff has released a number of reports that have addressed the potential for a pool fire at operating and decommissioning plants. These reports have been incomplete and technically deficient in a variety of ways. The Staff's October 2000 report corrected some, but not all, of the technical deficiencies in previous reports, and was incomplete in its analysis of pool risk. For example, it provided an incomplete and misleading assessment of the offsite consequences of a pool fire.

(21) For two decades the Staff and its consultants assumed that the most severe case of loss of water from a spent fuel pool would be a total, instantaneous loss of water. That assumption has distorted and rendered incomplete every NRC analysis of pool accident risk until the Staff's October 2000 report, which partially addressed the implications of a loss of water that is not total and instantaneous. As indicated above in paragraph 12, the Staff's October 2000 report considered the implications of flow blockage -- from collapsed structures or residual water -- on heat transfer, and concluded that comparatively old fuel can ignite.

(22) This conclusion represents an advance in the Staff's understanding of pool fires. However, the Staff's October 2000 report failed to analyze all of the implications of flow blockage for the onset and progression of a pool fire. Consider three examples. First, the role of residual water in blocking air flow has important implications for accident management, because there would be many scenarios in which the addition of water to a pool undergoing draining or evaporation would make the situation worse. Second, heatup of fuel that is partially submerged in water could lead to a fire that involves not a zirconium-air reaction but a zirconium-steam reaction, yielding hydrogen gas that could accumulate to explosive concentrations in surrounding buildings. Third, flow blockage could play an important role in the propagation of a fire from

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[12] Although recently-discharged fuel is more prone to ignition than older fuel, ignition can occur in older fuel over a wide range of conditions, given a loss of water from a pool.

comparatively recently-discharged fuel to older fuel, because a fire in recently-discharged fuel could lead to debris falling to the base of the pool, thereby blocking air flow to nearby fuel channels.

(23) Neither the Staff nor any other entity has ever made a comprehensive analysis of the potential for a reactor accident to cause a pool accident, the potential for a pool accident to cause a reactor accident, or the potential for a pool accident to cause another pool accident.[13] The first two potentials are important for operating plants, while the third potential is important for operating or decommissioning plants that have more than one pool. In the Harris license amendment proceeding, the Staff and CP&L have proffered analyses and arguments about the potential for a degraded-core accident at the Harris reactor to cause a pool fire. Deficiencies in these analyses are addressed later in this declaration.

Proposed Spent Fuel Pool Expansion at Harris

(24) There are four spent fuel storage pools at the Harris nuclear power plant. Only two of the pools, designated "A" and "B," are currently in operation. At present, pool A contains 6 PWR racks with a total of 360 spaces, and 3 BWR racks with a total of 363 spaces. Pool B contains 12 PWR racks with a total of 768 spaces and 17 BWR racks with a total of 2,057 spaces. Under the present license, one additional BWR rack with a total of 121 spaces could be placed in pool B.

(25) On 21 December 2000, CP&L received a license amendment to activate pools "C" and "D."[14] The purpose of the license amendment is to allow CP&L to use the Harris facility to store spent fuel generated at CP&L's one-unit Harris PWR station, its two-unit Brunswick BWR station, and its one-unit Robinson PWR station. The license amendment allows the placement in pool C of up to 11 PWR racks with a total of 927 spaces and 19 BWR racks with a total of 2,763 spaces; and the placement in pool D of 12 PWR racks with a total of 1,025 spaces. CP&L envisions this placement occurring in three campaigns in pool C, followed by two campaigns in pool D.[15]

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[13] Requirements for a comprehensive analysis of this kind are set forth in Section 3.1 of Thompson, 2000 (op cit).

[14] Amendment No. 103 to Facility Operating License No. NPF-63 for the Shearon Harris Nuclear Power Plant, Unit No. 1, 21 December 2000.

[15] Pool D would not be filled until a later "campaign," by which time CP&L would also need to have obtained a license amendment permitting it to exceed a 1.0 million BTU/hour limit on the heat load in pools C and D. At that point, however, no further licensing action would be needed in regard to the number of spent fuel assemblies permitted to be stored in pool D. The number of

(26) The license amendment would bring the total inventory of spent fuel assemblies that could be stored at Harris to 8,384, approximately double the current capacity of pools A and B; and over a thousand more spent fuel assemblies than assumed in the 1983 Final Environmental Statement ("FES") that was prepared in connection with the Harris operating license application.[16] Thus, the license amendment permits a significant increase in the quantity of long-lived radioactive isotopes (*e.g.*, cesium-137) that could be stored at the Harris plant.

(27) The present and proposed pool configuration at Harris involves the use of high-density racks. In pools A and B, the center-center distance in existing high-density racks is 10.5 inches for PWR fuel. For new high-density racks in pools C and D, the center-center distance proposed by CP&L is even closer: 9.0 inches for PWR fuel. In such closely-spaced racks, the suppression of criticality requires that each fuel assembly be surrounded by neutron-absorbing panels. If water is lost from a pool, the presence of these panels will suppress the convective circulation of air and steam. As a result, the zirconium cladding of the fuel can heat up and ignite, causing a pool fire.

Consideration of Pool Fires in the Harris License Amendment Proceeding

(28) In August 2000 the ASLB admitted into the Harris license amendment proceeding a contention that required the parties to address the potential for a pool fire in pool C and/or pool D at Harris. However, the ASLB also required the parties to confine their discussion of pool fires to a particular sequence of events. The postulated sequence involved a degraded-core accident at the Harris reactor with containment failure or bypass, leading to radioactive contamination of the Harris site to an extent that precludes actions needed to provide cooling or makeup to the pools, thereby causing a loss of water from the pools by evaporation, resulting in a pool fire. This sequence of events has been referred to by the ASLB and other parties as "the seven-part event sequence", and is hereafter given that designation.

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spent fuel assemblies permitted to be stored at the Harris site would have been previously approved in this license amendment proceeding.

[16] CP&L License Amendment Application, Enclosure 1 at 3 (23 December 1998); NUREG-0972, Final Environmental Statement Related to the Operation of Shearon Harris Nuclear Power Plant Units 1 and 2, Docket Nos. STN 50-400 and 50-401, Carolina Power and Light Company (October 1983).

(29) Other sequences of events could lead to a loss of water from pools at Harris, thereby causing a pool fire. I have made the following statement on this matter:[17]

> "A variety of events, alone or in combination, might lead to partial or complete uncovering of spent fuel in the Harris pools. Relevant types of event include:
>
> > (a) an earthquake, cask drop, aircraft crash, human error, equipment failure or sabotage event that leads to direct leakage from the pools;
> > (b) siphoning of water from the pools through accident or malice;
> > (c) interruption of pool cooling, leading to pool boiling and loss of water by evaporation; and
> > (d) loss of water from active pools into adjacent pools or canals that have been gated off and drained."

(30) The ASLB requested the parties to each provide a "best estimate" of the probability of the seven-part event sequence. No definition of a best estimate was provided by the ASLB.

(31) On behalf of Orange County, I provided a thorough discussion of the concept of a best estimate of probability in the context of severe accidents -- including pool fires -- at nuclear facilities.[18] That discussion included a review of the strengths and limitations of PRA, drawing widely from the relevant technical literature. I concluded the discussion with the following statement about the best estimate that could be provided for the probability of the seven-part event sequence:[19]

> "Thus, there will be no objectively correct estimate. For this event sequence, the best estimate of probability that can be provided is a range of numbers, reflecting a set of assumptions and the judgment of a particular group of people. If such an estimate is to have any value for decision-making purposes, it must be accompanied by a narrative that places the estimate in context. The narrative must explain the calculations and assumptions that underly the estimate, and must clearly identify the factors that limit the estimate's completeness and accuracy."

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[17] Thompson, 1999 (op cit), page C-1; Thompson, 2000 (op cit), page 10.
[18] Thompson, 2000 (op cit), pp 13-17.
[19] Thompson, 2000 (op cit), page 17.

(32) As part of providing the narrative that was called for in the preceding statement, I articulated a set of requirements for a comprehensive analysis of the seven-part event sequence.[20] I then concluded that none of the parties could perform such a comprehensive analysis in the time available, given the state of knowledge about relevant phenomena and processes.

(33) Having concluded that no party could, in the time window provided in this proceeding, perform a comprehensive analysis of the seven-part event sequence, I articulated an analytic approach that allowed a response by Orange County to the ASLB's request for a best estimate of probability.[21] The approach had three major elements. First, I would rely where possible on findings by CP&L and the NRC Staff, in order to maximize the area of common ground underlying the parties' findings. Second, I would employ scoping calculations at points in the analysis where appropriate findings from deterministic calculations or probabilistic models were not available.[22] Third, I would not attempt to perform a comprehensive analysis, but would instead analyze a single scenario for the seven-part event sequence.

(34) The third element of this approach deserves further explanation. I analyzed a single scenario not because other scenarios are unimportant, but because a comprehensive analysis of all scenarios could not be performed by any party within the constraints that were operative. However, my analysis of one scenario provided the ASLB with a minimum value for the best estimate of the overall probability that the seven-part event sequence will occur. Analysis of a second, independent scenario would yield a probability estimate that could be added to the first estimate, and this process could be repeated for other, independent scenarios.

(35) Consistent with the approach described in the two preceding paragraphs, I identified and analyzed, on behalf of Orange County, a particular scenario for the seven-part event sequence. This scenario involved the occurrence of a particular type of accident at the Harris reactor, namely a degraded-core accident in which, among other behaviors, the reactor coolant pressure remains high until or near to the time when severe core degradation begins. From a set of probabilistic safety assessment (PSA) documents that had been prepared by CP&L, I selected four types of degraded-core accident sequences as contributors

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[20] Thompson, 2000 (op cit), pp 18-23.

[21] Thompson, 2000 (op cit), page 24.

[22] A scoping calculation can provide a bridge between parts of an analysis that are deterministic or that rely on probabilistic modeling. Any scoping calculation must be consistent with physical principles and known phenomena, and must be transparent.

to the scenario.[23] I selected these sequences for two principal reasons. First, each sequence would involve a loss of spent fuel pool cooling, until or beyond the time when severe core degradation begins. Second, each sequence would have a significant probability of leading to a release of radioactive material from the containment via a temperature-induced steam generator tube rupture (TI-SGTR).

(36) CP&L and the NRC Staff took a different approach. Each of these parties proffered materials that purported to provide a comprehensive analysis of the seven-part event sequence. As I had predicted, neither party succeeded in providing a comprehensive analysis. Deficiencies in the analyses that were proffered by CP&L and the Staff are addressed later in this declaration. The analysis proffered by CP&L was summarized in a document prepared by ERIN Engineering, hereafter designated as the "ERIN report".[24] The analysis proffered by the Staff was summarized in an affidavit by Gareth Parry and other employees of the Staff; that document is hereafter designated as the "Parry affidavit".[25]

(37) The arguments presented by the parties revealed areas of agreement and disagreement. A notable area of agreement was that Orange County, the NRC Staff and CP&L agreed that a loss of water from pools C and D, leading to partial or total exposure of the spent fuel to air, would inevitably cause a pool fire. CP&L and the NRC staff presented this position as an assumption, without supporting analysis. CP&L claimed that its assumption was highly conservative. By contrast, Orange County based its position on deterministic analysis.

(38) Another important area of agreement by Orange County, the Staff and CP&L was that a fire in pools A and B would preclude actions needed to provide cooling and makeup to pools C and D, thus leading to loss of water from pools C and D by evaporation. This point of agreement is significant because, under some conditions, pools C and D would dry out more slowly than would pools A and B. Despite the possibly slower dryout of pools C and D, the parties agreed that the time period available for providing cooling and makeup, in order to prevent the onset of a fire in all Harris pools, would be the time period before

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[23] Thompson, 2000 (op cit), pp 24-26.

[24] ERIN Engineering and Research Inc, Technical Input for Use in the Matter of Shearon Harris Spent Fuel Pool Before the Atomic Safety and Licensing Board (Docket No. 50-400-LA), November 2000.

[25] Affidavit of Gareth W Parry, Stephen F LaVie, Robert Palla and Christopher Gratton in Support of NRC Staff Brief and Summary of Relevant Facts. Data and Arguments Upon Which the Staff Proposes to Rely at Oral Argument on Environmental Contention EC-6, ?? November 2000.

pools A and B dry out. CP&L assumed that the available time period would be four days.

(39) The principal area of disagreement among the parties was in their estimation of the conditional probability that a degraded-core reactor accident with containment failure or bypass would preclude actions that are needed to provide cooling or makeup to the Harris pools. For a selected set of degraded-core accident sequences in which containment is bypassed by TI-SGTR, Orange County found that this conditional probability would be one. As a result, Orange County estimated that the probability of a pool fire at Harris is comparable to the probability of a degraded-core accident with containment failure or bypass. CP&L and the NRC staff provided lower estimates for the probability of a pool fire.

Structure of the ASLB Order

(40) The ASLB Order has three sections, titled Background, Analysis and Conclusion. This declaration addresses the technical content of the ASLB Order, which can be found in Parts C, D and E of the Analysis section, and in the Conclusion. Part C of the Analysis section discusses each step in the seven-part event sequence, providing a summary of the ASLB's interpretation of the position of each party, and the ASLB's analysis. Part D discusses whether the probability of a pool fire at Harris is such that this event is remote and speculative. Part E discusses the 1989 NRC Staff study NUREG-1353.

Deficiencies in the ASLB Order

(41) The ASLB Order has numerous deficiencies, including misrepresentations and technical errors. In the following paragraphs, I discuss a number of these deficiencies. The discussion focusses on instances where the ASLB has failed to understand a technical issue, has misrepresented the position of Orange County, or has made a technical error. The ASLB Order is also deficient in that it uncritically accepts analyses and arguments proffered by CP&L and the NRC Staff. I address that issue by discussing, later in this declaration, deficiencies in the analyses proffered by CP&L and the Staff.

(42) A general deficiency in the ASLB Order is its inadequate specification for the making of a "best estimate" of the probability of a pool fire. At page 16, the Order states that the ASLB's request for a best estimate was intended to obtain the fruits of the type of analysis that the Staff would undertake in making an environmental assessment (EA) determination. The Order also states that "a full PRA analysis" is not needed for an EA determination. Thus, it appears that the

ASLB had decided, at the time of admitting contention EC-6, that the potential for a pool fire at Harris is a matter of limited importance, and that the probability of a pool fire can be estimated with a modest level of effort.

(43) The probability of a loss of water from the Harris pools is in contention in the Harris proceeding. However, the parties agree that a loss of water would lead to a fire in all four pools at Harris.[26] The offsite consequences of this fire would be a national disaster of historic proportions.[27] The fire would release to the atmosphere a quantity of long-lived radioactive isotopes -- including cesium-137 -- that would exceed by more than an order of magnitude the release from the 1986 Chernobyl accident. This release would render uninhabitable for decades a body of land whose area could exceed the area of North Carolina.[28] Thus, developing a thorough understanding of the potential for a pool fire at Harris is a matter of high importance.

(44) The overall probability of a pool fire at Harris cannot be estimated with a modest level of effort. Instead, a comprehensive analysis would be needed. I have articulated a set of requirements for such a comprehensive analysis of the seven-part event sequence.[29] Moreover, even a comprehensive analysis could not provide a single, objectively correct estimate for the probability of a pool fire. In paragraph 31, above, I have explained the limitations that will inevitably accompany such an estimate. In the Harris proceeding, Orange County has provided the ASLB with a minimum value for the best estimate of the probability of a pool fire via the seven-part event sequence, and has explained the limitations associated with that value.[30]

(45) The ASLB Order does not respond to Orange County's set of requirements for a comprehensive analysis of the seven-part event sequence. Instead, the Order states that a limited, unsophisticated analysis is sufficient. (See paragraph 42.) However, the ASLB's technical understanding of the relevant technical issues is weak, and the Board therefore has no basis for ignoring Orange County's position. Deficiencies in the ASLB's technical understanding are evident from later paragraphs in this declaration.

(46) An illustration of the ASLB's limited technical understanding is its understanding of the concept of probability. The ASLB discusses the

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[26] This statement assumes that fuel is present in each pool.

[27] Thompson, 2001 (op cit).

[28] Thompson, 1999 (op cit), Appendix E.

[29] Thompson, 2000 (op cit), pp 18-23.

[30] Thompson, 2000 (op cit), pp 42-43.

probabilities of events in the seven-part event sequence as though these are single, objectively correct numbers. That is a naive and erroneous view which ignores a large body of PRA literature. (See paragraph 31.) Given the grave consequences of a pool fire, the ASLB should be held to a higher standard in assessing probabilities.

(47) At pages 17-19, the ASLB Order addresses the potential occurrence of a degraded-core accident at the Harris reactor. In this discussion, the ASLB at first recognizes that Orange County has selected and analyzed only four types of degraded-core accident sequence. (See paragraph 35, above.) Subsequently, the ASLB misrepresents Orange County's position, by stating that the County's estimate of the overall probability of the four selected sequences is also the County's estimate of the probability of core degradation through all possible sequences. Also, the ASLB misrepresents Orange County's position about the loss of spent fuel pool cooling that accompanies the four selected sequences. In discussing these sequences, the ASLB states, at page 17, that all of them "lead finally to a loss of cooling to the fuel pools." To the contrary, each sequence involves a loss of cooling to the fuel pools from the beginning of the accident sequence until the occurrence of core degradation and potentially beyond. This point is significant because it bears upon the potential for recovery of pool cooling, and thereby on the probability of a pool fire. The ASLB's misinterpretation could have been avoided through the dialogue that occurs in an evidentiary hearing.

(48) At pages 19-21, the ASLB Order addresses the potential for containment failure or bypass, given the occurrence of a degraded-core accident. In this discussion, the ASLB notes that Orange County focussed its analysis on the potential for containment bypass by TI-SGTR. (See paragraph 35, above.) The ASLB views Orange County's analysis "as too simplistic for several reasons." The ASLB states that Orange County did not give "adequate consideration to the specific details of accident scenarios, containment and equipment configuration, and plant operating procedures that will affect the overall probability for containment failure or bypass." As an example, the ASLB states that Orange County did not consider procedural changes whereby CP&L will instruct operators to not run reactor coolant pumps during a degraded-core accident. The ASLB also expressed its dissatisfaction that Orange County did not link a variety of containment failure or bypass modes with specific degraded-core sequences. Each of these objections to Orange County's analysis represents a failure of the ASLB to understand that analysis.

(49) Orange County analyzed a selected scenario for the seven-part event sequence. The reasons for analyzing a selected scenario, and the characteristics

of the selected scenario, were clearly set forth in the County's submission to the ASLB. (See paragraphs 32-35, above.) Orange County had concluded that no party could conduct a comprehensive analysis within the operative constraints, and the County's conclusion was confirmed by the limited nature of the analyses proffered by CP&L and the Staff. For example, neither CP&L nor the Staff recognized the significance of TI-SGTR in the context of the seven-part event sequence, and neither presented a credible analysis of the potential for TI-SGTR. Apparently, the ASLB does not understand the limited nature of the CP&L and Staff analyses.

(50) For the selected scenario, Orange County's analysis of the potential for TI-SGTR drew directly from the NRC Staff study NUREG-1570.[31] That study did consider the relevant details of accident scenarios, equipment configuration and plant operating procedures. Orange County relied upon findings of NUREG-1570 that did not involve any assumption that reactor coolant pumps would operate during a degraded-core accident. Thus, CP&L's procedural changes regarding operation of these pumps (see paragraph 48, above) would either have no effect on the conditional probability of TI-SGTR for Orange County's selected sequences, or would increase the conditional probability. The ASLB does not recognize this point. It appears that the ASLB either did not read or did not understand NUREG-1570. The same appears to be true of the NRC Staff employees involved in the Harris proceeding. Paragraphs 97-100 of the Parry affidavit addressed TI-SGTR, and paragraph 100 mentioned NUREG-1570, but the findings of NUREG-1570 were not reflected in the affidavit. For example, the Parry affidavit assumed, contrary to the findings of NUREG-1570, that CP&L's procedural changes would lead to a low conditional probability of TI-SGTR.

(51) Footnote 5 of the ASLB Order addresses two technical issues. For each issue, the ASLB finds the position of Orange County to be without merit. The first issue is the effect of high levels of fuel burnup on the release of radioactive material from a reactor to the atmosphere during a degraded-core accident. The second issue is the onsite deposition of radioactive material that is released to the atmosphere via a containment bypass pathway. In both cases, the ASLB has not understood the technical issue, and has therefore inappropriately disregarded Orange County's position.

(52) At high levels of burnup, such as the levels now experienced at the Harris reactor, fuel tends to become highly fragmented or powdered. This property will have significant effects on the release of radioactive material to the

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[31] SGTR Severe Accident Working Group (NRC Staff), Risk Assessment of Severe Accident-Induced Steam Generator Tube Rupture, NUREG-1570, March 1998.

atmosphere during degraded-core accidents, and on the onsite deposition of that material. Orange County proffered two literature citations on this subject.[32] One was the NRC Staff study NUREG-1465.[33] The other was a paper by Schmitz and Papin.[34] Footnote 5 of the ASLB Order completely ignores NUREG-1465, and states that the Schmitz and Papin paper describes tests that that are not representative of conditions at Harris. If the ASLB had read and understood the Schmitz and Papin paper, it would know that the nature of the tests reported in the paper is not the source of the fragmentation and powdering of the fuel; instead, this property of the fuel results from high burnup. Of particular interest is the presence in high-burnup fuel of a peripheral zone that accounts for about 10 percent of the volume of the fuel pellets.[35] By ignoring NUREG-1465, and by failing to understand the Schmitz and Pappin paper, the ASLB has shown that it has no basis for disregarding Orange County's position on this issue.

(53) In their submissions neither CP&L nor the NRC Staff recognized the significance of the fact that Harris fuel is experiencing burnup levels such that fragmentation and powdering of the fuel can be expected. In analyzing the potential release of radioactive material from containment during a degraded-core accident, both parties used assumptions and methodologies that do not account for high-burnup effects and which are, therefore, obsolete. The ASLB Order does not recognize this point.

(54) In its footnote 5, the ASLB Order dismisses Orange County's position on the onsite deposition of radioactive material that is released to the atmosphere via a containment bypass pathway. Specifically, the ASLB states that Orange County's comments on the Staff's use of the ARCON computer model are "speculative, at best." In Appendix D of my report, I discussed the deficiencies of the ARCON model. The ARCON model is a "straight-line Gaussian" model for estimating the dispersion of an atmospheric plume. In other words, this model assumes that the plume travels in a straight line. By definition, the ARCON model cannot account for many of the plume behaviors that will occur if radioactive material is released to the atmosphere from the Harris containment. These behaviors will reflect the complex configuration of the exterior of the Harris plant, which features structures of various shapes and heights. Far from being speculative,

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[32] See Thompson, 2000 (op cit), page 28.

[33] L Soffer et al, Accident Source Terms for Light-Water Nuclear Power Plants, NUREG-1465, February 1995.

[34] Franz Schmitz and Joelle Papin, "High burnup effects on fuel behavior under accident conditions: the tests CABRI REP-Na", Journal of Nuclear Materials, Volume 270, 1999, pp 55-64.

[35] Thompson, 2000 (op cit), page D-3; Schmitz and Pappin, 1999 (op cit), page 58.

behaviors of this kind are in many cases quite familiar to a lay person. For example, one observes that an automobile with a comparatively flat rear surface tends to accumulate dirt on its rear window. Also, a pedestrian in a city with high-rise buildings often observes irregular wind patterns at street level. A straight-line plume model cannot capture either phenomenon. Thus, the ASLB has no basis for dismissing Orange County's position.

(55) Orange County has provided the ASLB with a discussion of a variety of phenomena that will affect the onsite deposition of radioactive material at Harris, pursuant to a degraded-core accident with containment bypass via TI-SGTR.[36] Relevant phenomena include building wake effects, fragmented/powdered fuel, aerosol agglomeration, plume rainout, and resuspension of deposited material. Only one of these phenomena is discussed in the ASLB Order, namely the presence of fragmented/powdered fuel. As shown in paragraph 52, above, the ASLB has not understood this phenomenon, and has inappropriately ignored Orange County's position. The ASLB has failed to understand the significance of the other phenomena. Similarly, neither CP&L nor the NRC Staff has accounted for any of these phenomena in their analyses.

(56) At pages 22-23, the ASLB order addresses the potential for loss of spent fuel pool cooling, given a degraded-core accident at the Harris reactor. The ASLB misrepresents Orange County's position, stating (at page 22) that the County claims that pool cooling would "become inoperative due to either failure of electric power on the site, causing a loss of power to the SFP cooling pumps, or unavailability of component cooling water to cool the SFP heat exchangers." To the contrary, for each of Orange County's four selected degraded-core sequences, component cooling water would be unavailable from the beginning of the accident sequence until the occurrence of core degradation and potentially beyond. This failure alone would ensure an absence of pool cooling for the same period. (See paragraph 47, above.) Moreover, additional failures could, as a separate matter, cause pool cooling to be unavailable. For example, 68 percent of the point estimate probability of Orange County's selected degraded-core sequences is associated with sequences that would be initiated by an earthquake or by in-plant flooding.[37] In these sequences, pool cooling would be rendered unavailable by several separate mechanisms, and would remain unavailable after core degradation, potentially for many days.

(57) The ASLB Order states, at page 23: "The Board is seriously troubled by BCOC's [Orange County's] claim of certainty -- its use of a probability of one --

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[36] Thompson, 2000 (op cit), pages D-3 and D-4.

[37] Thompson, 2000 (op cit), Table 1 (page 48).

that there will be a loss of SFP cooling as a result of a degraded core accident and containment failure." That statement demonstrates the ASLB's lack of understanding of the relevant technical issues, in two respects. First, the ASLB's statement misrepresents Orange County's position. For the County's selected degraded-core sequences, pool cooling would be lost not as a result of the accident but as an inevitable accompaniment to the accident, and would arise from the events that initiate the accident. Second, the probability of one for loss of pool cooling during these sequences derives directly from the PSA analysis performed by CP&L. (See paragraph 35, above.) The ASLB might reasonably be surprised by this probability of one, but the appropriate response would be to engage Orange County in dialogue, in order to understand the basis for the probability. Instead, the ASLB misrepresents the County's position, and dismisses that position without understanding it.[38]

(58) A further misrepresentation of Orange County's position occurs later on page 23 of the ASLB Order. The ASLB states that Orange County has argued "that the probability of losing SFP cooling is certain (i.e., 1.0) for all accident scenarios." The County has made no such argument, and has made it abundantly clear to the ASLB that the County has analyzed a single, selected scenario. Misrepresentations of this kind provide repeated evidence of the ASLB's lack of understanding of the relevant technical issues, and raise concerns about the ASLB's fairness.

(59) At pages 24-26, the ASLB Order addresses onsite radiation levels pursuant to a degraded-core accident with containment failure or bypass. This part of the Order is deficient in two major respects. First, it displays a lack of technical understanding, and misrepresents Orange County's position, regarding radiation dose inside the Harris control room and the Technical Support Center (TSC). Second, it uncritically endorses an NRC Staff analysis of radiation exposure, despite the failure of that analysis to account for important, relevant phenomena.

(60) The ASLB Order claims, at page 24, that Orange County's estimate of radiation dose inside the control room assumed an offsite power failure that interrupts control room ventilation. Orange County never stated or implied any such assumption, which exists only in the mind of the ASLB. Instead, the

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[38] The ASLB further shows its lack of understanding of the potential for beyond design basis accidents in another statement at page 23, where the Board claims that Orange County "seemingly ignores the fundamental benefits of engineered safety principles, such as physical separation, redundancy, and diversity in connection with equipment necessary for SFP cooling." Practical expeience and a very large body of PRA analysis show that beyond design basis accidents are credible events, despite the application of engineered safety features.

County provided the ASLB with an analysis of control room dose, habitability and functionality.[39] These factors are important in assessing the role of the control room pursuant to a degraded-core accident at Harris.[40] The County's analysis indicated that the radiation dose in the control room could arise from gamma shine through the control room roof, entry of contaminated air into the control room through the ventilation system, and/or infiltration of contaminated air through doors or other penetrations. Orange County pointed out that the control room ventilation system, including the emergency filtration system, could not accommodate the levels of radioactivity in the plume from a TI-SGTR release. The ASLB Order responds to none of this analysis by Orange County. Instead, it misrepresents the County's position in a manner that reveals the ASLB's lack of technical understanding. For example, the ASLB is evidently unaware that operation of the control room ventilation system could increase the dose in the control room.

(61) The ASLB Order describes and endorses an NRC Staff analysis of radiation exposure pursuant to a degraded-core accident. Indeed, at page 26, the ASLB Order uses the Staff's analysis as a standard of comparison by which to reject Orange County's analysis. However, the Staff's analysis fails to account for important, relevant phenomena. For example, the Staff's analysis does not account for fragmentation/powdering of high-burnup fuel. (See paragraph 53, above.) In considering containment bypass via the steam generators, the Staff's analysis does not account for phenomena such as building wake effects, aerosol agglomeration, plume rainout, and resuspension of deposited material. (See paragraph 55, above). The Staff's analysis uses a straight-line plume dispersion model that cannot capture important plume behaviors that will occur at Harris. (See paragraph 54, above.) By uncritically endorsing the Staff's analysis, the ASLB reveals its lack of technical understanding of the relevant issues.

(62) Orange County's analysis of onsite radiation exposure, pursuant to a degraded-core accident with a TI-SGTR release, did not purport to be a definitive analysis. Instead, the County's analysis relied on a scoping estimate for the onsite deposition of radioactive material. That scoping estimate assumed uniform deposition of material across a circular area. Clearly, a more

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[39] Thompson, 2000 (op cit), pp 29-32.

[40] Radiation dose, habitability and functionality issues must also be addressed in determining the role of the TSC. However, during the discovery phase of the Harris proceeding, CP&L did not provide the information that would be needed to fully investigate these issues for the TSC. This lack of information provides a further indication of the need for an evidentiary hearing, preceded by additional discovery.

sophisticated analysis would lead to a nonuniform distribution, with a pattern that reflects, among other factors, wind directions during and after the period of release. However, the Staff's methodology is not adequate for this situation. Orange County has used a conservative, scoping analysis, pending the development of a more sophisticated methodology. The Staff has used an analysis that purports to be definitive but does not capture important phenomena and is nonconservative. The ASLB, lacking understanding of the issues involved, has erroneously endorsed the Staff's analysis.

(63) At pages 27-31, the ASLB Order addresses the potential for provision of cooling and/or makeup to the Harris pools, given the existence of onsite radioactive contamination pursuant to a degraded-core accident with containment failure or bypass. Then, at pages 31-33, the Order addresses the loss of pool water by evaporation, if cooling or makeup cannot be provided. Both parts of the ASLB Order must be discussed together, because the ASLB addresses in the second part (pages 31-33) some issues that would logically be addressed in the first part (pages 27-31).

(64) A key point in this area of discussion is the maximum radiation dose that should be assumed for the purpose of the analysis. Orange County's technical submission to the ASLB has carefully addressed this issue.[41] The County has argued that the dose is foreseeable and should conform to normal occupational limits. The County's argument has legal and ethical dimensions, which I do not address in this declaration, but also relies on PRA practice. The ASLB Order does not respond to the part of the County's argument that relies on PRA practice.

(65) The ASLB Order, at page 30, misrepresents Orange County's position on the issue of a maximum dose. The ASLB claims that the County has argued that plant personnel would be unwilling to accept doses beyond normal occupational limits, in the event of an emergency. The County has not made that argument. Whether a particular level of dose beyond occupational limits will be accepted in a particular situation is a matter for speculation which is irrelevant to the County's position. It is well known that nuclear industry personnel have, on a number of occasions, knowingly accepted doses higher than regulatory limits. Firefighters did this during the 1986 Chernobyl accident, and some died as a result. In the Harris proceeding, however, the relevant question is the level of dose that should be assumed for the purpose of the analysis.

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[41] Thompson, 2000 (op cit), pp 19-22, pp 33-34, Appendix F.

(66) Another key point in this area is the need for a functioning command structure if there is to be any possibility of successful provision of pool cooling and/or makeup. Orange County's technical submission to the ASLB has carefully addressed this issue.[42] The ASLB Order acknowledges, at page 27, that Orange County has addressed this issue, but at no point in the Order is there any review of the County's analysis or any recognition of the significance of this issue. The only other mention of the command structure issue appears at page 33, where the ASLB states: "Even if CP&L loses the ability to run the plant from the control room there are procedures in place for both CP&L and the NRC to exercise command and control to make decisions about safeguarding SFP cooling integrity." There is no basis in either of the CP&L or NRC Staff submissions to support that statement. Neither submission provided an analysis of the command structure issue with a thoroughness approaching that of Orange County's analysis. To the extent that CP&L or the Staff touched upon this issue, Orange County provided a more complete analysis.

(67) At page 33, the ASLB Order states that there are "myriad ways" to provide makeup water to fuel pools. That statement ignores analysis by Orange County which shows that there is a high degree of dependency among the pool makeup options.[43] Nine options have been identified by CP&L. All six of the proceduralized options would rely on electrical power, although two of those options would allow a limited inventory of water to enter the pools by gravity. Two of the three nonproceduralized options would also rely on electrical power. Only one option -- a single diesel fire pump -- would not rely on electrical power. Every option would rely upon a functioning command structure. The ASLB does not recognize this high degree of dependency.

(68) At pages 28 and 32, the ASLB Order discusses the time periods that are available to provide makeup water to the Harris pools in the event of a loss of pool cooling, in order to avoid a pool fire. The ASLB uncritically mentions time periods of up to 116 days. Clearly, the ASLB has no understanding of an important area of agreement among the parties to the Harris proceeding. (see paragraph 38, above.) Orange County, the Staff and CP&L have agreed that a fire in pools A and B would preclude actions needed to provide cooling and makeup to pools C and D, thus leading to loss of water from pools C and D by evaporation. This point of agreement is significant because, under some conditions, pools C and D would dry out more slowly than would pools A and B. Despite the possibly slower dryout of pools C and D, the parties have agreed

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[42] Thompson, 2000 (op cit), pp 20-22, 32-38, Appendix F.

[43] Thompson, 2000 (op cit), pp 37-38.

that the time period available for providing cooling and makeup, in order to prevent the onset of a fire in all Harris pools, would be the time period before pools A and B dry out. CP&L assumed that the available time period would be 4 days.

(69) Orange County has carefully explained the technical basis for stating that a fire in pools A and B would inevitably lead to a fire in pools C and D.[44] As is characteristic of their analyses, CP&L and the NRC Staff have made short, qualitative statements on this matter.[45] Although the parties are in agreement, neither CP&L nor the Staff has provided a technical basis for its position. Nevertheless, the parties have agreed that a severe accident at one part of the Harris plant, namely a fire in pools A and B, would inevitably lead to a fire in pools C and D. CP&L and the Staff have not explained why this finding is so obvious that they need not justify it by technical analysis, while they simultaneously argue that a severe accident at the Harris reactor would almost certainly not lead to a pool fire. The ASLB is oblivious to this important issue.

(70) At pages 33-34, the ASLB Order addresses the probability that a pool fire will occur if water is lost from pools C and D by evaporation. The ASLB notes that the parties have agreed that this probability is one, CP&L and the Staff doing so with reservations. However, the ASLB exhibits no understanding that the parties have reached their positions in different ways. The positions of CP&L and the Staff are assumptions. By contrast, Orange County's position is a product of deterministic analysis.[46] The ASLB ignores this analysis, and misrepresents Orange County's position by stating that it is an assumption. As for many other issues in this proceeding, Orange County has produced a better analysis than that provided by the other parties. In response, the ASLB has misrepresented and obscured the County's analysis.

(71) At pages 36-39, the ASLB Order discusses whether the probability of a pool fire at Harris is such that this event is remote and speculative. Much of the discussion is about legal issues, which I do not address in this declaration. However, it is important to note that the ASLB, in assessing the probability of a pool fire, neglects all potential pool fires other than those which result from the seven-part event sequence. As stated in paragraph 29, above, other sequences of events could lead to a pool fire.

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[44] Thompson, 2000 (op cit), pp 39-40, Appendix G.

[45] ERIN report, pages 2-36 and D-1; Parry affidavit, paragraph 29.

[46] Thompson, 2000 (op cit), pp 40-42, Appendix H.

(72) At pages 39-40, the ASLB Order discusses the 1989 NRC Staff study NUREG-1353. At the Board's request, Orange County had commented on the relevance of NUREG-1353 to the Harris proceeding.[47] The County noted that the NUREG-1353 estimate for the probability of a pool fire -- 2×10^{-6} per [reactor] year -- could be added to the overall probability of the seven-part event sequence for Harris, because NUREG-1353 did not consider the seven-part event sequence.[48] It is significant that the NUREG-1353 probability estimate is an order of magnitude higher than the Staff estimate -- 2×10^{-7} per [reactor] year -- of the overall probability of the seven-part event sequence at Harris. This result, by itself, calls into question the ASLB's conclusion that a pool fire at Harris is a remote and speculative event.

Deficiencies in the Pool Fire Analyses Proffered by CP&L and the Staff

(73) Preceding paragraphs of this declaration have described numerous specific examples of deficiencies in the pool fire analyses proffered by CP&L and the NRC Staff. Both analyses also exhibit general deficiencies that are significant.

(74) CP&L's analysis purported to be a PRA-type study. However, the ERIN report and other documents that describe CP&L's analysis do not meet basic standards for documentation of a PRA. The analysis purported to be quantitative, but many of the key findings are expressed qualitatively. For example, the radiation dose incurred by plant personnel is a key parameter in analysis of the seven-part event sequence. Yet, CP&L's documents provide not a single number for radiation dose. Where findings of the analysis are expressed quantitatively, there typically are no supporting calculations. Thus, CP&L's analysis largely consists of assertions that lack supporting information. As a result, the analysis cannot be independently reviewed and its credibility is low. The ASLB does not acknowledge the low quality of CP&L's work, perhaps because the ASLB is unaware of the standards that should apply to a PRA.

(75) The NRC Staff's analysis was primarily qualitative. The major exception was a body of radiation dose calculations using the ARCON model.[49] These calculations were documented by the Staff in a reasonably clear format.

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[47] Thompson, 2000 (op cit), pp 43-46.

[48] Pool conditions (rack configuration and fuel loading) assumed in NUREG-1353 are not representative of the conditions that CP&L seeks to employ at Harris pools C and D. However, this difference would not lead to a significant difference in the probability of a pool fire.

[49] Some less significant calculations were alsoperformed by the Staff.

Unfortunately, however, the calculations shed no useful light on the seven-part event sequence, because the ARCON model cannot capture the relevant phenomena. (See paragraph 54, above.)

(76) Aside from the calculations mentioned in the preceding paragraph, the Parry affidavit provides the primary documentation of the Staff's analysis. Statements made in the Parry affidavit are predominantly qualitative, and there is frequent, explicit recourse to judgment and belief. A qualitative analysis of this type cannot be independently validated. Therefore, it does not provide an adequate basis for the Staff's refusal to prepare an EIS.

Irreparable Harm Caused by Granting of the Harris License Amendment

(77) A pool fire at Harris would be a national disaster of historic proportions, causing irreparable harm to people and the environment. (See paragraph 43, above.) The parties to the Harris proceeding agree that a fire would occur in all four pools at Harris if water were lost from at least one pool. (See paragraph 38, above.) The probability of a pool fire is in contention, but this declaration shows that Orange County's probability estimate is more credible than the estimates proffered by CP&L and the NRC Staff. The County estimates the probability of a pool fire to be comparable to the probability of a degraded-core reactor accident with containment failure or bypass. Granting of the Harris license amendment would lead to activation of pools C and D and, thereby, to an approximate doubling of the number of spent fuel assemblies stored in the Harris pools. (See paragraph 26, above.) As a result, the consequences of a pool fire at Harris would be significantly increased. This increase in consequences could be avoided if CP&L added dry storage capacity for spent fuel at one or more of its plant sites instead of employing high-density storage of spent fuel in pools C and D at Harris. Accordingly, granting of the Harris license amendment would create imminent, irreparable and unnecessary harm to people and the environment.

I declare, under penalty of perjury, that the foregoing facts are true and correct to the best of my knowledge and belief, and that the opinions expressed above are based on my best professional judgment.

Executed on 16 March 2001.

G. R. Thompson

Gordon Thompson

Attachment A

INSTITUTE FOR RESOURCE AND SECURITY STUDIES

Curriculum Vitae:
GORDON R. THOMPSON

July 2000

Professional expertise

Consulting technical and policy analyst in the fields of energy, environment, sustainable development, and international security.

Education

- D.Phil. in applied mathematics, Oxford University (Balliol College), 1973.
- B.E. in mechanical engineering, University of New South Wales, Sydney, Australia, 1967.
- B.Sc. in mathematics & physics, University of New South Wales, 1966.

Current appointment

- Executive director, Institute for Resource & Security Studies (IRSS), Cambridge, MA.

Project sponsors and tasks (selected)

- Massachusetts Water Resources Authority, 2000: evaluated risks associated with water supply and wastewater systems that serve greater Boston.
- Canadian Senate, Energy & Environment Committee, 2000: reviewed risk issues associated with the Pickering Nuclear Generating Station.
- Greenpeace International, Amsterdam, 2000: reviewed impacts associated with the La Hague nuclear complex in France.
- Orange County, NC, 1999-2000: assessed safety issues associated with spent fuel storage at the Harris nuclear plant.
- Government of Ireland, 1998-2000: developed framework for assessment of impacts and alternative options associated with the Sellafield nuclear complex in the UK.
- Clark University, Worcester, MA, 1998-1999: participated in review of a foundation's grant-making related to climate change.

- UN High Commissioner for Refugees, 1998: developed a strategy for conflict management in the CIS region.
- General Council of County Councils (Ireland), W Alton Jones Foundation (USA), and Nuclear Free Local Authorities (UK), 1996- 1998: assessed safety and economic issues of nuclear fuel reprocessing in the UK; assessed alternative options.
- Environmental School, Clark University, Worcester, MA, 1996: session leader at the Summer Institute, "Local Perspectives on a Global Environment".
- Greenpeace Germany, Hamburg, 1995-1996: a study on war, terrorism and nuclear power plants.
- HKH Foundation, New York, and Winston Foundation for World Peace, Washington, DC, 1994-1996: studies and workshops on preventive action and its role in US national security planning.
- Carnegie Corporation of New York, Winston Foundation for World Peace, Washington, DC, and others, 1995: collaboration with the Organization for Security and Cooperation in Europe to facilitate improved coordination of activities and exchange of knowledge in the field of conflict management.
- World Bank, 1993-1994: a study on management of data describing the performance of projects funded by the Global Environment Facility (joint project of IRSS and Clark University).
- International Physicians for the Prevention of Nuclear War, 1993-1994: a study on the international control of weapons-usable fissile material.
- Government of Lower Saxony, Hannover, Germany, 1993: analysis of standards for radioactive waste disposal.
- University of Vienna (using funds supplied by the Austrian government), 1992: review of radioactive waste management at the Dukovany nuclear plant, Czech Republic.
- Sandia National Laboratories, 1992-1993: advice to the US Department of Energy's Office of Foreign Intelligence.
- US Department of Energy and Battelle Pacific Northwest Laboratories, 1991-1992: advice for the Intergovernmental Panel on Climate Change regarding the design of an information system on technologies that can limit greenhouse gas emissions (joint project of IRSS, Clark University and the Center for Strategic and International Studies).
- Winston Foundation for World Peace, Boston, MA, and other funding sources, 1992-1993: development and publication of recommendations for strengthening the International Atomic Energy Agency.
- MacArthur Foundation, Chicago, IL, W. Alton Jones Foundation, Charlottesville, VA, and other funding sources, 1984-1993: policy

analysis and public education on a "global approach" to arms control and disarmament.

- Energy Research Foundation, Columbia, SC, and Peace Development Fund, Amherst, MA, 1988-1992: review of the US government's tritium production (for nuclear weapons) and its implications.
- Coalition of Environmental Groups, Toronto, Ontario (using funds supplied by Ontario Hydro under the direction of the Ontario government), 1990-1993: coordination and conduct of analysis and preparation of testimony on accident risk of nuclear power plants.
- Greenpeace International, Amsterdam, Netherlands, 1988-1990: review of probabilistic risk assessment for nuclear power plants.
- Bellerive Foundation, Geneva, Switzerland, 1989-1990: planning for a June 1990 colloquium on disarmament and editing of proceedings.
- Iler Research Institute, Harrow, Ontario, 1989-1990: analysis of regulatory response to boiling-water reactor accident potential.
- Winston Foundation for World Peace, Boston, MA, and other funding sources, 1988-1989: analysis of future options for NATO (joint project of IRSS and the Institute for Peace and International Security).
- Nevada Nuclear Waste Project Office, Carson City, NV (via Clark University, Worcester, MA), 1989-1990: analyses of risk aspects of radioactive waste management and disposal.
- Ontario Nuclear Safety Review (conducted by the Ontario government), Toronto, Ontario, 1987: review of safety aspects of CANDU reactors.
- Washington Department of Ecology, Olympia, WA, 1987: analysis of risk aspects of a proposed radioactive waste repository at Hanford.
- Natural Resources Defense Council, Washington, DC, 1986-1987: preparation of testimony on hazards of the Savannah River Plant.
- Lakes Environmental Association, Bridgton, ME, 1986: analysis of federal regulations for disposal of radioactive waste.
- Greenpeace Germany, Hamburg, 1986: participation in an international study on the hazards of nuclear power plants.
- Three Mile Island Public Health Fund, Philadelphia, PA, 1983-1989: studies related to the Three Mile Island nuclear plant.
- Attorney General, Commonwealth of Massachusetts, Boston, MA, 1984-1989: analyses of the safety of the Seabrook nuclear plant.
- Union of Concerned Scientists, Cambridge, MA, 1980-1985: studies on energy demand and supply, nuclear arms control, and the safety of nuclear installations.
- Conservation Law Foundation of New England, Boston, MA, 1985: preparation of testimony on cogeneration potential at a Maine papermill.

- Town & Country Planning Association, London, UK, 1982-1984: coordination and conduct of a study on safety and radioactive waste implications of the proposed Sizewell nuclear plant.
- US Environmental Protection Agency, Washington, DC, 1980-1981: assessment of the cleanup of Three Mile Island Unit 2 nuclear plant.
- Center for Energy & Environmental Studies, Princeton University, Princeton, NJ, and Solar Energy Research Institute, Golden, CO, 1979-1980: studies on the potentials of renewable energy sources.
- Government of Lower Saxony, Hannover, FRG, 1978-1979: coordination and conduct of studies on safety aspects of the proposed Gorleben nuclear fuel cycle center.

Other experience (selected)

- Principal investigator, project on "Exploring the Role of 'Sustainable Cities' in Preventing Climate Disruption", involving IRSS and three other organizations, 1990-1991.
- Visiting fellow, Peace Research Centre, Australian National University, 1989.
- Principal investigator, Three Mile Island emergency planning study, involving IRSS and Clark University, Worcester, MA, 1987-1989.
- Co-leadership (with Paul Walker) of a study group on nuclear weapons proliferation, Institute of Politics, Harvard University, 1981.
- Foundation (with others) of an ecological political movement in Oxford, UK, which contested the 1979 Parliamentary election.
- Conduct of cross-examination and presentation of evidence, on behalf of the Political Ecology Research Group, at the 1977 Public Inquiry into proposed expansion of the reprocessing plant at Windscale, UK.
- Conduct of research on plasma theory (while a PhD candidate), as an associate staff member, Culham Laboratory, UK Atomic Energy Authority, 1969-1973.
- Service as a design engineer on coal-fired plants, New South Wales Electricity Commission, Sydney, Australia, 1968.

Publications (selected)

- *Hazard Potential of the La Hague Site: An Initial Review*, a report for Greenpeace International, May 2000.
- *A Strategy for Conflict Management: Integrated Action in Theory and Practice* (with Paula Gutlove), Working Paper No. 7, IRSS, Cambridge, MA, March 1999.

- *Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant,* a report for Orange County, NC, February 1999.
- *High Level Radioactive Liquid Waste at Sellafield: Risks, Alternative Options and Lessons for Policy,* IRSS, Cambridge, MA, June 1998.
- "Science, democracy and safety: why public accountability matters", in F. Barker (ed), *Management of Radioactive Wastes: Issues for local authorities,* Thomas Telford, London, 1998.
- "Conflict Management and the OSCE" (with Paula Gutlove), *OSCE/ODIHR Bulletin,* Volume 5, Number 3, Fall 1997.
- *Safety of the Storage of Liquid High-Level Waste at Sellafield* (with Peter Taylor), Nuclear Free Local Authorities, UK, November 1996.
- *Assembling Evidence on the Effectiveness of Preventive Actions, their Benefits, and their Costs: A Guide for Preparation of Evidence,* IRSS, Cambridge, MA, August 1996.
- *War, Terrorism and Nuclear Power Plants,* Working Paper No. 165, Peace Research Centre, Australian National University, Canberra, October 1996.
- "The Potential for Cooperation by the OSCE and Non-Governmental Actors on Conflict Management" (with Paula Gutlove), *Helsinki Monitor,* Volume 6 (1995), Number 3.
- "Potential Characteristics of Severe Reactor Accidents at Nuclear Plants", "Monitoring and Modelling Atmospheric Dispersion of Radioactivity Following a Reactor Accident" (with Richard Sclove, Ulrike Fink and Peter Taylor), "Safety Status of Nuclear Reactors and Classification of Emergency Action Levels", and "The Use of Probabilistic Risk Assessment in Emergency Response Planning for Nuclear Power Plant Accidents" (with Robert Goble), in D. Golding, J. X. Kasperson and R. E. Kasperson (eds), *Preparing for Nuclear Power Plant Accidents,* Westview Press, Boulder, CO, 1995.
- *A Data Manager for the Global Environment Facility* (with Robert Goble), Environment Department, The World Bank, June 1994.
- *Preventive Diplomacy and National Security* (with Paula Gutlove), Winston Foundation for World Peace, Washington, DC, May 1994.
- *Opportunities for International Control of Weapons-Usable Fissile Material,* ENWE Paper #1, International Physicians for the Prevention of Nuclear War, Cambridge, MA, January 1994.
- "Article III and IAEA Safeguards", in F. Barnaby and P. Ingram (eds), *Strengthening the Non-Proliferation Regime,* Oxford Research Group, Oxford, UK, December 1993.
- *Risk Implications of Potential New Nuclear Plants in Ontario* (prepared with the help of eight consultants), a report for the Coalition of Environmental

Groups, Toronto, submitted to the Ontario Environmental Assessment Board, November 1992 (3 volumes).

- *Strengthening the International Atomic Energy Agency,* Working Paper No. 6, IRSS, Cambridge, MA, September 1992.
- *Design of an Information System on Technologies that can Limit Greenhouse Gas Emissions* (with Robert Goble and F. Scott Bush), Center for Strategic and International Studies, Washington, DC, May 1992.
- *Managing Nuclear Accidents: A Model Emergency Response Plan for Power Plants and Communities* (with six other authors), Westview Press, Boulder, CO, 1992.
- "Let's X-out the K" (with Steven C. Sholly), *Bulletin of the Atomic Scientists,* March 1992, pp 14-15.
- "A Worldwide Programme for Controlling Fissile Material", and "A Global Strategy for Nuclear Arms Control", in F. Barnaby (ed), *Plutonium and Security,* Macmillan Press, UK, 1992.
- *No Restart for K Reactor* (with Steven C. Sholly), Working Paper No. 4, IRSS, Cambridge, MA, October 1991.
- *Regulatory Response to the Potential for Reactor Accidents: The Example of Boiling-Water Reactors,* Working Paper No. 3, IRSS, Cambridge, MA, February 1991.
- *Peace by Piece: New Options for International Arms Control and Disarmament,* Working Paper No. 1, IRSS, Cambridge, MA, January 1991.
- *Developing Practical Measures to Prevent Climate Disruption* (with Robert Goble), CENTED Research Report No. 6, Clark University, Worcester, MA, August 1990.
- "Treaty a Useful Relic", *Bulletin of the Atomic Scientists,* July/August 1990, pp 32-33.
- "Practical Steps for the 1990s", in Sadruddin Aga Khan (ed), *Non-Proliferation in a Disarming World,* Proceedings of the Groupe de Bellerive's 6th International Colloquium, Bellerive Foundation, Geneva, Switzerland, 1990.
- *A Global Approach to Controlling Nuclear Weapons,* Occasional Paper published by the Institute for Resource and Security Studies, October 1989.
- *IAEA Safety Targets and Probabilistic Risk Assessment* (with three other authors), Greenpeace International, Amsterdam, August 1989.
- *New Directions for NATO* (with Paul Walker and Pam Solo), published jointly by IRSS and the Institute for Peace and International Security (both of Cambridge, MA), December 1988.
- "Verifying a Halt to the Nuclear Arms Race", in F. Barnaby (ed), *A Handbook of Verification Procedures,* Macmillan Press, UK, 1990.

- "Verification of a Cutoff in the Production of Fissile Material", in F.Barnaby (ed), *A Handbook of Verification Procedures*, Macmillan Press, UK, 1990.
- "Severe Accident Potential of CANDU Reactors," Consultant's Report in *The Safety of Ontario's Nuclear Power Reactors*, Ontario Nuclear Safety Review, Toronto, February 1988.
- *Nuclear-Free Zones* (edited with David Pitt), Croom Helm Ltd, Beckenham, UK, 1987.
- *Risk Assessment Review For the Socioeconomic Impact Assessment of the Proposed High-Level Nuclear Waste Repository at Hanford Site, Washington* (edited; written with five other authors), prepared for the Washington Department of Ecology, December 1987.
- *The Nuclear Freeze Revisited* (written with Andrew Haines), Nuclear Freeze and Arms Control Research Project, Bristol, UK, November 1986. Variants of the same paper have appeared as Working Paper No. 18, Peace Research Centre, Australian National University, Canberra, February 1987, and in *ADIU Report*, University of Sussex, Brighton, UK, Jan/Feb 1987, pp 6-9.
- *International Nuclear Reactor Hazard Study* (with fifteen other authors), Greenpeace, Hamburg, Federal Republic of Germany (2 volumes), September 1986.
- "What happened at Reactor Four" (the Chernobyl reactor accident), *Bulletin of the Atomic Scientists*, August/September 1986, pp 26-31.
- *The Source Term Debate: A Report by the Union of Concerned Scientists* (with Steven C. Sholly), Union of Concerned Scientists, Cambridge, MA, January 1986.
- "Checks on the spread" (a review of three books on nuclear proliferation), *Nature*, 14 November 1985, pp 127-128.
- Editing of *Perspectives on Proliferation*, Volume I, August 1985, published by the Proliferation Reform Project, IRSS.
- "A Turning Point for the NPT ?", *ADIU Report*, University of Sussex, Brighton, UK, Nov/Dec 1984, pp 1-4.
- "Energy Economics", in J. Dennis (ed), *The Nuclear Almanac*, Addison-Wesley, Reading, MA, 1984.
- "The Genesis of Nuclear Power", in J. Tirman (ed), *The Militarization of High Technology*, Ballinger, Cambridge, MA, 1984.
- *A Second Chance: New Hampshire's Electricity Future as a Model forthe Nation* (with Linzee Weld), Union of Concerned Scientists, Cambridge, MA, 1983.
- *Safety and Waste Management Implications of the Sizewell PWR* (prepared with the help of six consultants), a report to the Town & Country Planning Association, London, UK, 1983.

- *Utility-Scale Electrical Storage in the USA: The Prospects of Pumped Hydro, Compressed Air, and Batteries,* Princeton University report PU/CEES #120, 1981.
- *The Prospects for Wind and Wave Power in North America,* Princeton University report PU/CEES # 117, 1981.
- *Hydroelectric Power in the USA: Evolving to Meet New Needs,* Princeton University report PU/CEES # 115, 1981.
- Editing and part authorship of "Potential Accidents & Their Effects", Chapter III of *Report of the Gorleben International Review,* published in German by the Government of Lower Saxony, FRG, 1979--Chapter III available in English from the Political Ecology Research Group, Oxford, UK.
- *A Study of the Consequences to the Public of a Severe Accident at a Commercial FBR located at Kalkar, West Germany,* Political Ecology Research Group report RR-1, 1978.

Expert presentations and testimony (selected)

- UK Consensus Conference on Radioactive Waste Management, 1999: provided invited testimony on information and decision-making.
- Joint Committee on Public Enterprise and Transport, Irish Parliament, 1999: provided invited testimony on nuclear fuel reprocessing and international security.
- UK and Irish Parliaments, 1998: gave members' briefings on risks and alternative options associated with nuclear fuel reprocessing in the UK.
- Center for Russian Environmental Policy, Moscow, 1996: presentation at a forum in parallel with the G-7 Nuclear Safety Summit.
- Lacey Township Zoning Board, New Jersey, 1995: testimony regarding radioactive waste management.
- Ontario Court of Justice, Toronto, Ontario, 1993: testimony regarding Canada's Nuclear Liability Act.
- Oxford Research Group, seminar on "The Plutonium Legacy", Rhodes House, Oxford, UK, 1993: presentation on nuclear safeguards.
- Defense Nuclear Facilities Safety Board, Washington, DC, 1991: testimony regarding the proposed restart of K-reactor, Savannah River Site.
- Conference to consider amending the Partial Test Ban Treaty, United Nations, New York, 1991: presentation on a global approach to arms control and disarmament.
- US Department of Energy, hearing on draft EIS for new production reactor capacity, Columbia, SC, 1991: presentation on tritium need and implications of tritium production options.

- Society for Risk Analysis, 1990 annual meeting, New Orleans, special session on nuclear emergency planning: presentation on real-time techniques for anticipating emergencies.
- Parliamentarians' Global Action, 11th Annual Parliamentary Forum, United Nations, Geneva, 1990: presentation on the potential for multilateral nuclear arms control.
- Advisory Committee on Nuclear Facility Safety, public meeting, Washington, DC, 1989: submission on public access to information and on government accountability.
- Peace Research Centre, Australian National University, seminar on "Australia and the Fourth NPT Review Conference", Canberra, 1989: proposal of a universal nuclear weapons non-proliferation regime.
- Carnegie Endowment for International Peace, Conference on "Nuclear Non-Proliferation and the Role of Private Organizations", Washington, DC, 1989: options for reform of the non-proliferation regime.
- US Department of Energy, EIS scoping hearing, Columbia, SC, 1988: appropriate scope of an EIS for new production reactor capacity.
- International Physicians for the Prevention of Nuclear War, 6th and 7th Annual Congresses, Koln, FRG, 1986 and Moscow, USSR, 1987: relationships between nuclear power and the threat of nuclear war.
- County Council, Richland County, SC, 1987: implications of severe reactor accidents at the Savannah River Plant.
- Maine Land Use Regulation Commission, 1985: cogeneration potential at facilities of Great Northern Paper Company.
- Interfaith Hearings on Nuclear Issues, Toronto, Ontario, 1984: options for Canada's nuclear trade and Canada's involvement in nuclear arms control.
- Sizewell Public Inquiry, UK, 1984: safety and radioactive waste implications of the proposed Sizewell nuclear plant.
- New Hampshire Public Utilities Commission, 1983: electricity demand and supply options for New Hampshire.
- Atomic Safety & Licensing Board, US Nuclear Regulatory Commission, 1983: use of filtered venting at the Indian Point nuclear plants.
- US National Advisory Committee on Oceans and Atmosphere, 1982: implications of ocean disposal of radioactive waste.
- Environmental & Energy Study Conference, US Congress, 1982: implications of radioactive waste management.

Miscellaneous

- Married, two children.

- Extensive experience in public speaking before professional and lay audiences, and in interviews with print and broadcast journalists.
- Author of numerous newspaper, newsletter, and magazine articles and book reviews.

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