ATTACHMENT 1

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radiological health

Preparedness and Response in Radiation Accidents

NATIONAL CENTER FOR DEVICES AND RADIOLOGICAL HEALTH

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Food and Drug Administration

001616

HHS Publication FDA 83-8211

Preparedness and Response in Radiation Accidents

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WHO Collaborating Centers for:
- Standardization of Protection Against Nonionizing Radiations
- Training and General Tasks in Radiation Medicine
- Nuclear Medicine

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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001617

requires specialized skills and equipment. For accidents at nuclear power plants where local communities are likely to have these skills and equipment, and the licensee definitely does, partial social preparedness is possible. This is less likely for a radiological transportation accident because one cannot be sure where they might occur. Interestingly, except for social preparedness, the characteristics of radiological transport accidents and floods are similar.

Table 1.1-2 Characteristics of selected hazardous events (from Reference 9)

Characteristic	Nuclear power plant accident	Radiological transport accident	Earthquake	Flood
Scope of impact	Narrow or widespread	Narrow	Widespread	Narrow
Speed of onset	Gradual	Sudden	Sudden	Sudden or gradual
Duration of impact	Long	Short (although variable)	Short or repeated	Short (although variable)
Social preparedness	Partial	No	No	Yes
Secondary impacts	Yes: physical and public health (radiation)	Yes: physical and public health (radiation)	Yes: physical and public health	Yes: physical and public health

In addition to the characteristics cited in Table 1.1-2, all hazardous events exhibit the same phases of social response; that is, threat detection, threat evaluation, information dissemination (notification), and response (9). Radiological transportation accidents, given the remoteness of many accident sites from the location of skilled personnel and equipment, can be expected to have a longer period between occurrence and notification of appropriate responders than an accident at a nuclear power plant.

While radiation accidents cause important secondary impacts that differ from other hazardous events, radiation accidents need to be treated within a community emergency planning context for all hazardous events. As has been shown, the myriad of similarities in the characteristics of all accidents makes radiation emergency planning most sensible in a broad overall emergency planning concept.

1.1.3 The Probability and Consequences of Nuclear Power Reactor Accidents

The risk to the public from a radiation accident must consider three factors: (1) the probability of a sequence of undesirable events occuring, (2) the consequences of these events, and (3) the action taken to mitigate the consequences of the accident.

$$\text{Risk}\left(\frac{\text{accident consequences}}{\text{unit time}}\right) = \text{probability}\left(\frac{\text{events}}{\text{unit time}}\right) \times \text{magnitude}\left(\frac{\text{accident consequences}}{\text{event}}\right)$$

001618

Nuclear power reactor accidents are best discussed in terms of specific accident classes. Postulated reactor accidents have been classified by the NRC and are addressed in the agency's review of a nuclear power reactor applicant's environmental report (10). These accident classes are shown in Table 1.1-3. Class 1 accidents are of minor consequence, whereas Class 8 events are considered the most serious category to be considered by the applicant. Class 8 accidents are called Design Basis Accidents or DBA's. Class 9 accidents are a hypothetical sequence of successive failures leading to releases of radioactivity generally, but not always, of a greater magnitude than DBA's. The Reactor Safety Study (WASH-1400, the RSS, or the Rasmussen report), considers these accidents in terms of their probability and consequences (11). Accidents at Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR) equivalent to NRC's Class 9 accidents are the Reactor Safety Study's release categories PWR 1 through 7 and BWR 1 through 4. The Reactor Safety Study's release categories PWR 8 and 9 and BWR 5 are essentially NRC Class 8 or a DBA and do not pertain to core-melt sequences. They have marginal offsite consequences unless unique and unfavorable weather conditions exist at the time of the release.

Table 1.1-3 Classification of postulated nuclear power plant accidents (from Reference 10)

Class	Description	Examples	RSS Class
1	Trivial incidents	Small spills and leaks inside the containment	--
2	Small releases outside the containment	Small spills and leaks outside the containment	--
3	Radwaste system failures	Equipment leakage or malfunction, release from gas or liquid waste storage tank	--
4	Fission products to primary system (BWR)	Fuel cladding defects, off-design transients inducing fuel failures	--
5	Fission products to primary and secondary systems (PWR)	Fuel cladding defects and steam generator leaks, off-design transients, steam generator tube rupture	--
6	Refueling accidents	Fuel assembly drop, heavy object drop onto fuel in core	--
7	Spent-fuel handling accident	Fuel assembly drop in storage pool, heavy object drop onto fuel rack, fuel cask drop	--
8	Accident-initiation events considered in design-basis evaluation in the Safety Analysis Reports	Loss-of-coolant accidents (small and large), control rod ejection (PWR) or drop (BWR), steam line breaks (BWR), outside containment (PWR)	PWR 8-9 BWR 5
9	Hypothetical sequence of successive failures more severe than those postulated for establishing the design basis		PWR 1-7 BWR 1-4

001619

These six exposure modes may be further classified into plume exposure (modes 1, 2, and 3 above) and ground exposure (modes 4 through 6). Often cloudshine, noble gas exposure, and groundshine are characterized as direct exposure pathways since there are no intermediate vectors, such as air, food, or drinking water, to carry radioactive materials into the body. Alternatively, the inhalation and ingestion modes of exposure are indirect with exposure occurring because of the entrance of radioactive material into the body through air, food, or drinking water.

The Reactor Safety Study consequence model allows the input of site specific or assumed population data as a function of distance from the reactor site. Release magnitudes, timing, and other parameters that characterize release categories are found in the RSS. The RSS describes the progression of the cloud of radioactive material from the containment structure during and following a reactor accident. A standard Gaussian dispersion model is used to calculate ground-level airborne concentrations of radioactive material downwind of the reactor site. Weather input to the model is based on hourly meteorological readings for a 1-year period at seven selected reactor sites (11).

For the most part, core-melt accidents of the "melt-through" types (PWR 6 and 7) or "atmospheric" types (PWR 1 through 5) describe the broad classes of accident sequences of consequence to emergency planners. This is because core overheating or melting and loss of containment integrity following a Loss-of-Coolant-Accident (LOCA) could release significant quantities of radioactive material to the atmosphere. Containment failure can result from melt-through of the containment vessel by molten fuel. It can also result from inadequate isolation of containment openings, a reactor steam explosion, hydrogen burning, and overpressure which, in turn, cause a release of radioactive materials to the atmosphere. The information and conclusions for BWR accidents under the same mode of containment failure would be similar to PWR's.

Release categories (PWR 6 and 7) comprising the "melt-through" category, have a relatively long time after initiation of the accident before release occurs (10-12 hours), long "continuous" release durations (10 hours), and relatively small fractions of core radioisotope inventories released. In contrast, release categories (PWR 1 through 5) comprising the "atmospheric" release category, are assigned short times after initiation of the accident before release occurs (2-5 hours), short "puff" release durations (0.5-4 hours), and larger release fractions of core inventories (11).

The mean projected whole-body and thyroid doses at various distances from a reactor accident site to a person located outdoors for the "melt-through" release categories can be calculated from the data in the RSS (16). These are shown in Figures 1.1-1 and 1.1-2 for the whole-body and thyroid gland. These show exposures from pathways of importance early in an accident. The food pathway is not shown. These doses are relatively low because of the release of only small fractions of core radioisotope inventories in "melt-through" reactor accidents. The term "sheltering factor," or SF, referred to in the figures is the ratio of the dose with shelter to that without shelter. Shelter here means an ordinary building not a specially constructed fallout shelter. Projected thyroid doses are about an order of magnitude greater than whole-body doses. Mean thyroid doses are calculated for an exposed adult. The mean thyroid dose for children ages 1-10 would be about twice as high. At 1 mile the projected mean whole-body dose is about 1.5 rem and the thyroid dose is about 25 rem for this release category of nuclear power reactor accidents.

Figures 1.1-3 and 1.1-4 present the mean projected whole-body and thyroid doses versus distance for "atmospheric" release category accidents. Projected thyroid doses are 20 to 50 times the projected whole-body doses. At 100 miles downwind from a reactor accident, the projected mean whole-body dose is somewhat less than 2 rem, while the mean projected thyroid dose is about 100 rem. At 10 miles, these doses are 140 and 2000 rem respectively.

001620

inhaled can be substantially reduced, will also not provide much protection. Only thyroid blocking (or evacuation with very small delay times) can provide large reductions in the projected dose to the thyroid from this category of nuclear power plant accidents.

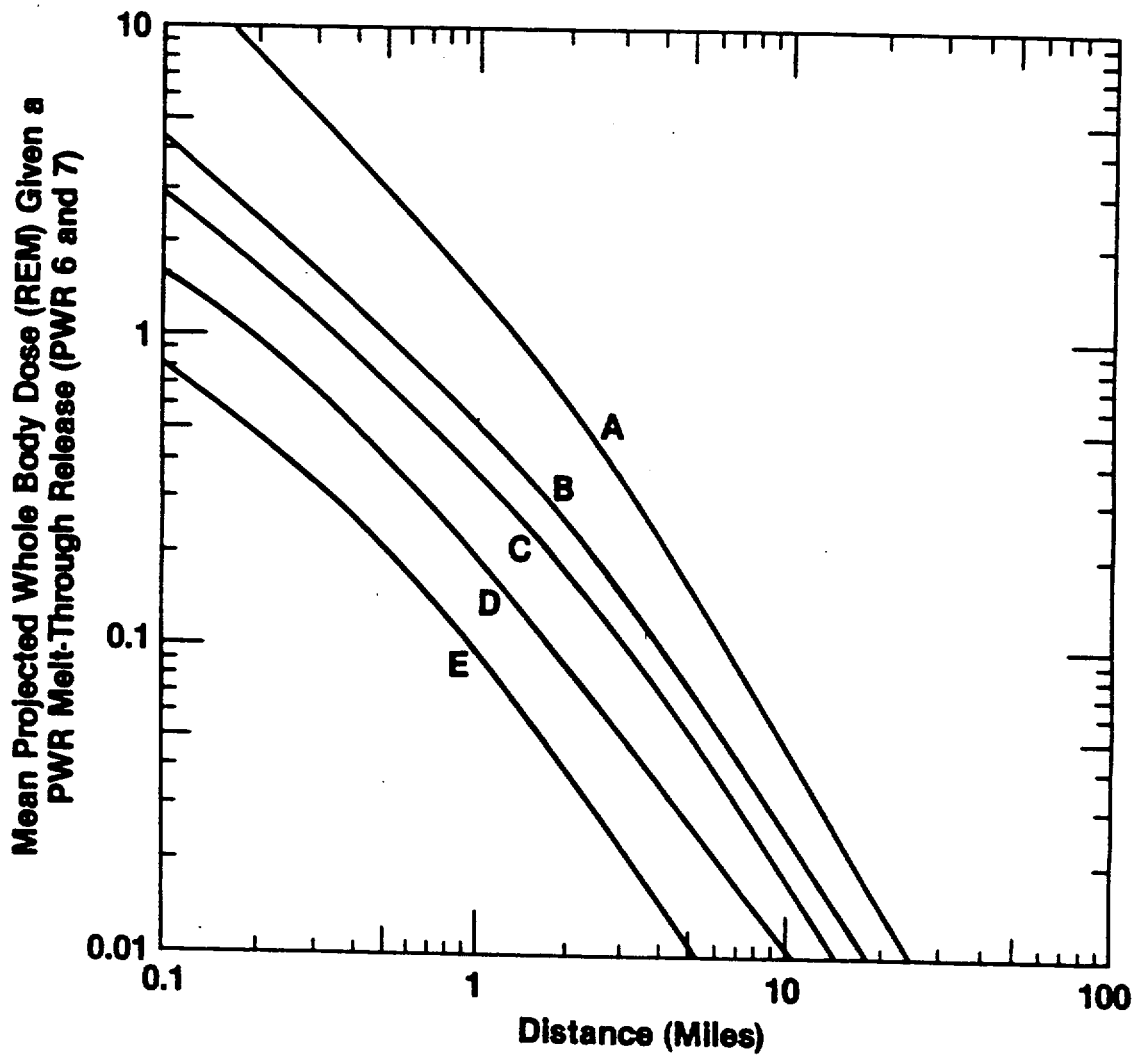

Figure 3.5-8 Conditional mean projected whole-body dose versus distance for sheltering and evacuation strategies. Projected doses are conditional on a PWR "melt-through" release (PWR 6 and 7) (from Reference 102).

Curve A Individual located outdoors without protection. SF's (1.0, 0.7). 1-day exposure to radionuclides on ground.

Curve B Sheltering, SF's (0.75, 0.33), 6-hour exposure to radionuclides on ground.

Curve C Sheltering, SF's (0.5, 0.08), 6-hour exposure to radionuclides on ground.

Curve D Evacuation, 5-hour delay time, 10 mph.

Curve E Evacuation, 3-hour delay time, 10 mph.

001621

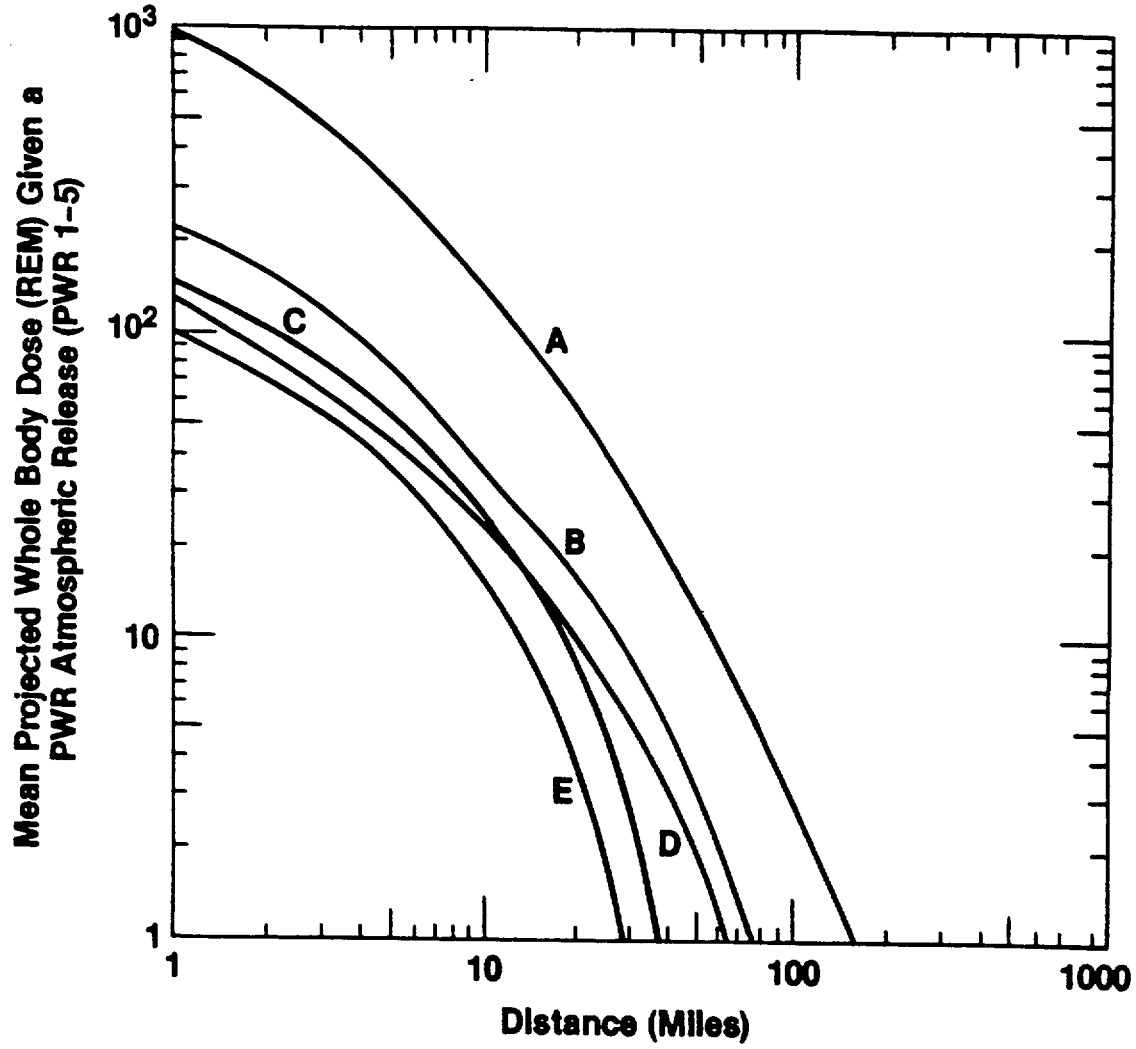

Figure 3.5-10 Conditional mean projected whole-body dose versus distance for sheltering and evacuation strategies. Projected doses are conditional on a PWR "atmospheric" release (PWR 1-5) (from Reference 102).

Curve A Individual located outdoors without protection. SF's (1.0, 0.7). 1-day exposure to radionuclides on ground.

Curve B Sheltering, SF's (0.75, 0.33), 6-hour exposure to radionuclides on ground.

Curve C Evacuation, 5-hour delay time, 10 mph.

Curve D Sheltering, SF's (0.5, 0.08), 6-hour exposure to radionuclides on ground.

Curve E Evacuation, 3-hour delay time, 10 mph.

001622

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001623

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

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

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing "Applicant's Response to BCOC's Late-Filed Environmental Contentions" were served on the persons listed below by U.S. mail, first class, postage prepaid, and by electronic mail transmission, this 3rd day of March, 2000.

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February 12, 1999

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE NRC STAFF

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

ORANGE COUNTY'S COMMENTS IN OPPOSITION TO NO SIGNIFICANT HAZARDS DETERMINATION AND CONDITIONAL REQUEST FOR A STAY OF EFFECTIVENESS

INTRODUCTION

Pursuant to 10 C.F.R. § 50.92(a)(2), Orange County, North Carolina, hereby submits the following comments in opposition to the Nuclear Regulatory Commission's ("NRC's" or "Commission's") proposed No Significant Hazards determination regarding a proposed license amendment to permit expansion of spent fuel storage capacity at the Shearon Harris nuclear power plant. The proposed license amendment and finding of no significant hazards considerations were noticed in the Federal Register on January 13, 1999, 64 Fed. Reg. 2,237. These comments are supported by the attached Declaration of Dr. Gordon Thompson (February 12, 1999) (hereinafter "Thompson Declaration").

The proposed No Significant Hazards finding should be withdrawn because the operational changes allowed by the proposed license fail to satisfy any of the three criteria in 10 C.F.R. § 50.92 for dispensing with a prior hearing. The finding should also be withdrawn because the proposed amendment does not satisfy the NRC's standard for a categorical exemption from the procedural requirements of the National Environmental Policy Act ("NEPA"), as set forth in 10 C.F.R. § 51.22(c). Therefore, as required by NEPA and 10 C.F.R.

§ 51.25, the Staff must prepare an Environmental Impact Statement ("EIS") or an Environmental Assessment ("EA") prior to issuing the proposed license amendment. Finally, the issuance of a license amendment prior to the conduct of a hearing in this case exceeds the purpose and authority granted by Congress in passing the *Sholly* amendment to the Atomic Energy Act.

In the event that the NRC Staff rejects these comments and decides to go ahead with a final finding that the license amendment poses no significant hazards considerations, Orange County requests the Staff to stay the effectiveness of the proposed license amendment for ten days, in order to maintain the status quo while the County appeals the Staff's decision.

FACTUAL BACKGROUND

Carolina Power & Light ("CP&L") has applied for a license amendment that would allow it to increase the spent fuel storage capacity at the Harris plant, by adding rack modules to spent fuel pools C and D and placing the pools in service.[1] Pools C and D were part of the original Harris design, intended to serve the plant's Units 2 and 3. Unit 2 and 3 were cancelled, and therefore the pools have remained empty. Now CP&L seeks to use the pools for storing spent fuel from the Harris reactor, as well as the Brunswick and Robinson reactors.

CP&L seeks modifications to the plant's design to allow it to install racks and store up to 8,405 spent fuel assemblies in Pools C and D. In order to meet NRC safety requirements, the plant's design would have to be modified to provide cooling by the component cooling water ("CCW") system for Unit 1. Because the CCW system has a limited heat load capacity, CP&L would alter its tech specs to impose administrative limits on the heat load in pools C and D, such

[1]For a more detailed description of the proposed license amendment, *see* Thompson Declaration, section E.

that they would not exceed 1.0 million BTU/hour.[2] CP&L also seeks permission to use coolant piping installed some years ago for Unit 2, for which quality assurance documentation has been either lost or purged.

The January 13, 1999, Federal Register notice sets forth the reasons why the NRC Staff believes the proposed amendment poses no significant hazards. It also offers interested members of the public an opportunity to request a hearing on the proposed license amendment. The Federal Register notice provides no indication that the Staff has performed any environmental review under NEPA: the notice contains no reference to an EIS, EA, or Finding of No Significant Impact ("FONSI").

Simultaneously with the filing of these comments, Orange County has filed a Request for Hearing and Petition to Intervene regarding the proposed license amendment. Orange County's Request for Hearing and Petition to Intervene (February 12, 1999). The County seeks a prior hearing on the safety and environmental issues raised by the proposed license amendment, including all of the concerns raised in these No Significant Hazards comments.

ARGUMENT

I. THE PROPOSED LICENSE AMENDMENT DOES NOT SATISFY THE NRC'S STANDARD FOR A DETERMINATION OF NO SIGNIFICANT HAZARDS CONSIDERATIONS.

Under Section 189a of the Atomic Energy Act, the issuance of a license or license amendment must await the conclusion of any public hearing that is granted. 42 U.S.C. § 4432(a)(1). Pursuant to the "*Sholly*" amendment to Section 189a, 42 U.S.C. § 4432(a)(2), the NRC may issue a license amendment *prior* to the hearing, if it finds the amendment would pose

[2]At some later point, CP&L plans to upgrade the CCW to accommodate a larger heat load.

"no significant hazards considerations." The NRC standard for making a No Significant Hazards determination is found in 10 C.F.R. § 50.92, which provides that the NRC may make find that a license amendment poses no significant hazards considerations if it would not:

> (1) Involve a significant increase in the probability or consequences of an accident previously evaluated;
> (2) Create the possibility of a new or different kind of accident from any accident previously evaluated; or
> (3) Involve a significant reduction in a margin of safety.

As discussed in the attached Declaration of Dr. Gordon Thompson, none of these criteria is satisfied by the proposed license amendment.

A. The Staff Fails to Show That the Operation of the Facility In Accordance With the Proposed License Amendment Would Not Involve a Significant Increase in the Probability or Consequences of an Accident Previously Evaluated.

In the Federal Register notice, the Staff concludes that operation of the Harris facility in accordance with the proposed license amendment would not involve a significant increase in the probability or consequences of an accident previously evaluated. As discussed in the Thompson Declaration, this claim is false, for several reasons. Activation of pools C and D will roughly double the total number of fuel handling operations to be conducted at Harris. Assuming that the general nature of fuel handling operations continues as before, the probability of a fuel assembly drop or misloaded fuel assembly, integrated over the entire period of the Harris operating license, will increase significantly, by a factor of two. If probability is integrated over the remaining period of the Harris operating license, rather than over its total duration, then activation of pools C and D will more than double the probability of a fuel assembly drop or a misloaded fuel assembly. The probability of a criticality accident will also be more than doubled, and the consequences of a criticality accident may also be significantly increased. Thompson Declaration, par. 42.

Moreover, activation of pools C and D will add to the electrical load and CCW heat load of existing Harris systems. It will also add to the burden of work on the Harris operators. These effects will increase the probability of two categories of accidents. First, they will significantly increase the probability of accidents associated with the Harris reactor, because the reactor's CCW and electrical systems and its operators will be under greater stress. Second, they will significantly increase the probability of accidents at the Harris pools that are attributable to interruptions in cooling and electricity supply and to increased operator stress. Thompson Declaration, par. 43.

The Staff is also incorrect in stating that the consequences of accidents will not increase. To the extent that severe accidents have been previously evaluated, their consequences will be significantly increased by the activation of pools C and D. The fuel storage capacity of these pools will roughly double the storage capacity at Harris, creating the potential for a doubled inventory of radioactivity. Severe accidents could affect some or all of the Harris pools. Thus, the potential doubling of radioactivity in the pools could significantly increase the consequences of such accidents. Thompson Declaration, par. 44.

B. The Staff Fails to Show That the Operation of the Facility In Accordance With the Proposed License Amendment Would Not Create the Possibility of a New or Different Kind of Accident From Any Accident Previously Evaluated.

Under its regulations, the NRC may not make a no significant hazard determinations if it finds that a proposed license amendment would create even the *possibility* of a new or different kind of accident not previously evaluated. The Staff may not rationalize the amendment by addressing the merits of how likely the accident is to occur. *San Luis Obispo Mothers for Peace v. U.S. NRC*, 799 F.2d 1268 (9th Cir. 1986).

According to the Federal Register notice, the only kind of accident that might conceivably be considered new is the accidental drop of a fuel rack; but that accident was already considered in relation to pool B. 64 Fed. Reg. at 2,239. Thus, the Staff concludes that the proposed license amendment would not create the possibility of a new or different kind of accident from any accident previously evaluated. As discussed in Section J of the Thompson Declaration, this conclusion is incorrect, for several reasons.

First, it does not appear that there has been any site-specific evaluation of the probability or consequences of severe accidents at pools A and B at Harris. The NRC has performed evaluations of accidents involving loss of water from fuel pools, generically and for sites other than Harris. However, these evaluations are seriously deficient because they failed to consider partial uncovering of fuel. *See* Thompson Declaration, Sections G and H. Thus, at pools A and B there exists the possibility of new or different kinds of accident from any accident previously evaluated. The same possibility will exist at pools C and D if these are activated. Severe accidents at some or all of the Harris pools could lead to offsite radiation exposure an order of magnitude larger than the exposure from the Chernobyl accident.

Second, the addition of pools C and D to the Unit 1 cooling system creates the possibility of a new accident that was not previously considered. As Dr. Thompson points out, the IPE and IPEEE studies performed for Harris did not address the provision of backup electrical power and CCW service to pools C and D. As Dr. Thompson points out, the need to provide cooling to pools C and D will place increased stress on the CCW system and backup diesel generators as well as the plant operators during a design basis loss of coolant accident ("LOCA"), thereby creating the possibility of a new accident.

C. The Staff Fails to Show That the Operation of the Facility In Accordance With the Proposed License Amendment Would Not Involve a Significant Reduction in a Margin of Safety.

The Staff's conclusion that the operation under the license amendment would not involve a reduction in a safety margin is without merit. The information provided in the license amendment application clearly demonstrates that the plant's safety margin would be significantly reduced by the proposed license amendment. As discussed in the Thompson Declaration, Section I, activation of pools C and D will create an additional heat load on the existing CCW system. CP&L proposes to meet this load in the short term by exploiting the margin in the CCW system. The safety margin will be reduced even further if, during a LOCA, the operators must divert water from the RHR to the spent fuel pools. This will increase stress on the operators and create opportunities for human error. Thus, the reduction in the CCW safety margin caused by the increased heat load is significant. Certainly, the NRC has provided no reason to conclude that it is not significant.[3]

The Staff fails to address the impact on the margin of safety caused by CP&L's proposal to use a cooling system for pools C and D using piping that will not satisfy ASME code requirements. *See* Thompson Declaration, pars. 23 and 50. As Dr. Thompson observes, this action could potentially cause a significant reduction in margins of safety for pool cooling. CP&L's alternative analysis has not been subjected to any public scrutiny or rigorous review. It deserves, at the least, thorough consideration at a licensing hearing before the license amendment

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[3] Moreover, as pools C and D become filled and the reactor receives a power uprate, the load on the CCW system will increase further. CP&L offers no assurance that the present margin of safety will be restored by upgrading the CCW system to accommodate these burdens.

is issued.

The margin of safety is also affected by CP&L's proposal to provide electrical service to pools C and D from the existing Unit 1 system, which includes the Unit 1 dedicated emergency diesel generators. These diesel generators already serve the safety systems in Unit 1 and spent fuel storage pools A and B. By adding pools C and D to the load carried by the Unit 1 diesel generators, CP&L would add stress on the diesel generators and on the plant operators in the event of a loss of offsite power. These effects could significantly reduce the margin of safety at the Harris reactor and the fuel pools.

II. THE PROPOSED NO SIGNIFICANT HAZARDS FINDING FAILS TO MEET THE NRC'S STANDARD FOR AN EXEMPTION FROM THE PROCEDURAL REQUIREMENTS OF NEPA.

The Federal Register notice makes no mention of NEPA or its requirements to issue an EIS or EA in support a proposed federal action that may significantly affect the quality of the human environment. Presumably, the Staff believes that it is exempt from the requirement to prepare an EIS or EA under 10 C.F.R. § 51.22(c)(9)(i). This provision allows the NRC to forego preparation of an EIS or EA "with respect to installation or use of a facility component located within the restricted area, as defined in part 20" of NRC regulations, if, *inter alia,* the amendment "involves no significant hazards consideration."

As demonstrated in Dr. Thompson's Declaration, the proposed amendment fails to satisfy any of the criteria for a finding of No Significant Hazards considerations. Therefore, the NRC Staff erred in relying on the exemption.

Moreover, an EIS or EA must be prepared because the proposed license amendment entails more than redesigning the Harris plant and installing and activitating a spent fuel cooling

system. It also involves the importation of a significant quantity of spent nuclear power plant fuel from other nuclear power plants around the area, and the doubling of the inventory of spent fuel on the site. In fact, if the license amendment is granted, the Shearon Harris plant would become the largest spent fuel storage facility east of the Mississippi River. As recognized in *Vermont Yankee Nuclear Power Corporation* (Vermont Yankee Nuclear Power Station), LBP-88-19, 28 NRC 145 (1988), there is no "independent utility" to the racking of a spent fuel pool: the only reason for the application is to permit the expansion of spent fuel storage at the plant. While the importation of additional spent fuel is not covered by the license amendment application, it is the intended result of the amendment. To narrowly focus the NEPA inquiry on the racking and cooling of the spent fuel pools would constitute unlawful segmentation of the NEPA decisionmaking process. *Id.* However, this is just what the NRC Staff apparently did in determining that no EIS or EA is required in this case.

The NEPA questions that Orange County would raise in a hearing on the application include issues relating to the risk of the proposed cooling system; the impacts of foreseeable severe accidents involving a greatly increased inventory of spent fuel on the site, including the impacts of an accident involving partial drainage of the spent fuel pools; the impacts of transporting and handling additional fuel; the environmental risks raised by using materials lacking proper QA certification; and the need for the increased spent fuel pool capacity.[4]

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[4]With respect to need, CP&L asserts in Enclosure 1 to its license amendment application that it has implemented a spent fuel shipping program "because DOE spent fuel storage facilities are not available and are not expected to be available in the foreseeable future." This assertions contradicts the Commission's Waste Confidence decision, which forbids challenges to the NRC's assumption that a federal repository will be available by the first quarter of the 21st century. The conflict between CP&L's assertion and the Waste Confidence decision must be addressed in a public hearing before the amendment can be allowed to go forward.

III. THE PROPOSED ISSUANCE OF A LICENSE PRIOR TO COMPLETION OF A HEARING EXCEEDS THE AUTHORITY GRANTED BY THE SHOLLY AMENDMENT.

The *Sholly* amendment to the Atomic Energy Act allows the Commission to issue a license amendment before completion of a hearing if it finds the amendment would pose "no significant hazards considerations," and directs the Commission to promulgate implementing regulations. The language of 10 C.F.R. § 50.92 provides that the Commission "may" make a determinatin that no significant hazards considerations are involved, if it finds that the criteria for such a determination are met. However, the regulations do not *require* a determination in every case where the criteria are satisfied.

Even if the Staff finds that the criteria are satisfied here, it should withdraw the proposed finding in this case, because there are no circumstances warranting the immediate issuance of a license amendment before a hearing can be held. As former Commissioner Asselstine has previously pointed out, Congress intended the *Sholly* amendment to the Atomic Energy Act to have limited purposes:

> In requesting the enactment of the *Sholly* amendment, the Commission described in some detail the actions in which it foresaw a need for this authority. The Commission emphasized the need for a large number of unforeseen and unanticipated changes to the detailed technical specifications in the operating licenses for nuclear power plants that arise each year through such activities as refueling of the plant. The Commission argued that the need to hold a hearing on each of these changes, if one is requested, would be burdensome to the Commission and could disrupt the operation of a number of plants. In order to avoid this problem, the Commission asked the Congress to reinstate the authority that the Commission had exercised in similar situations since 1962. *A reracking amendment is substantially different from the situations described by the Commission in requesting the Sholly amendment because reracking involves a substantial physical modification to the plant and because the need for reracking can be anticipated.*

Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-86-12, 24 NRC 1, 17,Separate Views of Commissioner Asselstine (1986) (emphasis added).

Commissioner Asselstine also pointed out language in the legislative history indicating that Congress did not intend the *Sholly* amendment to apply to the reracking of spent fuel pools. *Id.* at 16.

Even assuming for purposes of argument that the No Significant Hazards criteria are met, the circumstances of this case raise a number of potentially significant safety issues that should be addressed in a public hearing before the license amendment is issued, including design modifications that would add a significant demand load to safety cooling and electrical backup systems, use of cooling pipe whose quality assurance documentation is missing, the lack of any previous assessment of the impacts of partial drainage of the spent fuel pools on an extremely large inventory of spent fuel.

Moreover, there is no particular urgency to this license amendment. The proposed changes are to take place over an extended period of time. Even if the changes are perceived by CP&L as urgent, they could have been anticipated years before. Under the circumstances, there is no justification for issuing the license amendment before a hearing can be conducted.

IV. IF THE STAFF ISSUES A FINAL DETERMINATION OF NO SIGNIFICANT HAZARDS CONSIDERATIONS, IT SHOULD STAY THE EFFECTIVENESS OF THE DETERMINATION FOR TEN DAYS PENDING ORANGE COUNTY'S APPEAL.

In the event that the Staff rejects these comments and decides to finalize the proposed No Significant Hazards determination, Orange County requests the Staff to stay the effectiveness of the finding for ten days, in order to maintain the status quo while Orange County prepares an appeal of the determination. Orange County further requests that the Staff respond to this request at least ten days before issuing the license amendment, so that Orange County may be apprised of the need to take appropriate alternative measures to preserve the status quo.

V. CONCLUSION

For the foregoing reasons, the Staff should withdraw the proposed determination of no significant hazards considerations for the proposed amendment to the Shearon Harris operating license. If the Staff decides to deny this request, it should stay the effectiveness of its determination for ten days to preserve the status quo while appeals are taken.

Respectfully submitted,

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February 12, 1999

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE NRC STAFF

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

DECLARATION OF DR. GORDON THOMPSON

I, Gordon Thompson, declare as follows:

A. 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. This Declaration pertains to an application by Carolina Power and Light (CP&L) for an amendment to Facility Operating License No. NPF-63, which covers the Shearon Harris nuclear power plant. The staff of the Nuclear Regulatory Commission (NRC) has reviewed CP&L's application and proposes to determine that the amendment request involves no significant hazards consideration. The NRC has sought public comments on the proposed determination.[1] Through this Declaration, I offer comments on the NRC staff's proposed determination. I have prepared these comments pursuant to an agreement by IRSS to provide technical information and other services to Orange County, North Carolina.

B. My Professional Background

3. 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.

[1] Federal Register: January 13, 1999 (Volume 64, Number 8), pages 2237-2241.

4. During my professional career, I have performed technical and policy analyses on a range of issues related to international security, energy supply, environmental protection, and sustainable use of natural resources. 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. My CV is provided here as Attachment A.

C. Scope of My Review

5. In preparation of this Declaration, I reviewed the NRC's Federal Register notice for the proposed license amendment, the Final Safety Analysis Report for the Shearon Harris Nuclear Power Plant, the Final Environmental Statement related to the operation of Shearon Harris Nuclear Power Plant, Units 1 and 2 (NUREG-0972, October 1983), and CP&L's application for the proposed license amendment. I also reviewed various correspondence and technical documents relating to the propose license amendment and to risks of spent fuel storage, which are identified below.

6. The information that has been provided by the NRC and CP&L to date does not contain all of the detail that I would need to provide a complete, final statement about the hazards associated with the proposed license amendment. I would expect to review the full body of detailed evidence and present my final evaluation in the context of a hearing. However, even the limited information provided so far is adequate to permit me to identify serious safety concerns which preclude the NRC from making a "no significant hazards" determination. These issues should be addressed through the systematic, public process that a prior licensing hearing can provide.

D. The "No Significant Hazards" Standard

7. The NRC has stated its standard for determining that a license amendment request involves no significant hazards consideration.[2] The standard is met if operation of the facility in accordance with the proposed amendment would not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated; or (2) create the possibility of a new or different kind of accident from any accident previously evaluated; or (3) involve a significant reduction in a margin of safety.

8. In my professional opinion, based on the preliminary evidence provided by the NRC and CP&L, operation of the Shearon Harris plant in accordance with the license amendment proposed by CP&L will violate all three of the conditions set forth in the preceding paragraph. Therefore, the NRC staff should reverse its position and should

[2] Ibid.

determine that CP&L's license amendment request does not involve no significant hazards consideration.

E. The License Amendment in Context - Spent Fuel Management at Harris

9. Before discussing my concerns about the safety implications of the proposed license amendment, I provide here some background information about spent fuel management at the Harris plant and CP&L's proposal to increase the spent fuel storage capacity at Harris. Unless specified otherwise, the information presented here is drawn from CP&L's license amendment application or from CP&L's Final Safety Analysis Report (FSAR) for the Harris plant.

10. The Harris plant features one pressurized-water reactor (PWR). The core of this reactor contains 157 fuel assemblies, with a center-center distance of about 8.5 inches. The Harris plant was to have four reactors but only one was built. A fuel handling building was built to serve all four reactors. This building contains four fuel pools (A, B, C, D), a cask loading pool and three fuel transfer canals, all interconnected but separable by gates. Pools A and B contain fuel racks. Pools C and D are flooded but do not contain racks. The cooling and water cleanup systems for pools C and D were never completed.

11. Pool A now contains six PWR racks (360 fuel assembly spaces) and three BWR racks (363 spaces), for a total pool capacity of 723 fuel assemblies. Pool B contains twelve PWR racks (768 spaces) and seventeen BWR racks (2,057 spaces), and is licensed to store one additional BWR rack (121 spaces), for a total pool capacity of 2,946 fuel assemblies. Thus, pools A and B now have a combined capacity of 3,669 fuel assemblies. The center-center distance in pools A and B is 10.5 inches for PWR fuel and 6.25 inches for BWR fuel.

12. Pools A and B store spent fuel from the Harris reactor and from CP&L's Brunswick plant and Robinson plant. The Brunswick plant has two boiling-water reactors (BWRs) while the Robinson plant has one PWR. Shipment of spent fuel from Brunswick and Robinson to Harris is said by CP&L to be necessary to allow core offload capacity in the pools at Brunswick and Robinson.

13. CP&L seeks an amendment to its operating license so that it can activate pools C and D at Harris. By activating these pools, CP&L expects to have sufficient spent fuel storage capacity for all four CP&L reactors (Harris, Robinson and the two Brunswick reactors) through the end of their current operating licenses.

14. CP&L plans to install racks in pool C in three campaigns (approximately in 2000, 2005 and 2014), to create 927 PWR spaces and 2,763 BWR spaces, for a total pool capacity of 3,690 fuel assemblies. Thereafter, CP&L plans to install racks in pool D in two campaigns (approximately in 2016 and at a date to be determined), to create 1,025 PWR spaces. Thus, the ultimate capacity of pools C and D will be 4,715 fuel assemblies. The center-center distance will be 9.0 inches for PWR fuel and 6.25 inches for BWR fuel.

15. The PWR racks in pools C and D have a smaller center-center distance than the racks in pools A and B (9.0 inches instead of 10.5 inches). This arrangement allows more PWR fuel to be placed in a given pool area but also means that PWR fuel in pools C and D is more prone to undergo criticality. In response, CP&L proposes to include in the Technical Specifications for Harris a provision that PWR fuel will not be placed in pools C and D unless it has relatively low enrichment and high burnup.[3]

F. Some Technical Safety Issues Raised By the Proposed License Amendment

16. CP&L's plan for the activation of pools C and D raises a variety of technical safety issues. This section of my Declaration describes some of those issues. Later parts of the Declaration relate these issues to the NRC's standard for a "no significant hazards" determination.

17. NRC regulations require that spent fuel storage pools must be cooled by safety grade cooling systems. When the Harris plant was designed, the intention was that pools C and D would be cooled by the component cooling water (CCW) system for the second unit of the Harris plant.[4] That unit was never built, and therefore the Unit 2 CCW system does not exist. In the absence of a second CCW system, CP&L plans to cool pools C and D by connecting their cooling systems to the CCW system of the first unit. This system already provides cooling to pools A and B and serves other, important safety functions. Attachment B provides supporting information.[5] It should be noted that CP&L considered, but has not pursued, the option of cooling pools C and D by a new, independent system that could have had dedicated emergency diesel generators. Attachment C provides information in support of this point.[6] Three significant safety issues are raised by the fact that the spent fuel pool cooling arrangement originally designed for pools C and D of the Harris plant was not completed. These issues relate to the heat loading of the existing CCW system, the load on the existing emergency diesel generators, and the loss of some important quality assurance documentation for cooling piping at pools C and D.

18. **Heat load.** According to CP&L's license amendment application, the bounding heat load from the fuel in pools C and D will be 15.6 million BTU/hour.[7] At present, the CCW system cannot absorb this additional heat load. Thus, CP&L proposes to include in

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[3] License amendment application, Enclosure 5.

[4] The Harris pools have their own closed-circuit cooling systems, which can transfer heat to the relevant CCW system through heat exchangers.

[5] Attachment B is a portion of a set of viewgraphs (titled "Harris Spent Fuel Pool 'C' and 'D' Activation") shown by CP&L representatives during a meeting with NRC staff on 16 July 1998.

[6] Attachment C is an NRC staff memo about a meeting between CP&L representatives and NRC staff on 3 March 1998, together with a portion of a set of viewgraphs (titled "HNP Spent Fuel Pool 'C' and 'D' Activation") shown by CP&L during that meeting.

[7] License amendment application, Enclosure 7, page 5-16.

the Technical Specifications for Harris an interim provision that the heat load in pools C and D will not be allowed to exceed 1.0 million BTU/hour.[8] CP&L claims that an additional heat load of 1.0 million BTU/hour can be accommodated by the existing CCW system, and that the fuel to be placed in pools C and D will not create a heat load exceeding 1.0 million BTU/hour through 2001.

19. Apparently, CP&L contemplates a future upgrade of the CCW system, so that the CCW system can accommodate an additional heat load of 15.6 million BTU/hour from pools C and D. This contemplated upgrade is not described in the present license amendment application. Attachment C indicates that CP&L plans to perform the upgrade of the CCW system concurrent with a power uprate for the Harris reactor. Apparently, a 4.5 percent power uprate will be associated with steam generator replacement, and there will be a subsequent further power uprate of 1.5 percent. A chart in Attachment C shows that the projected CCW heat load, including the reactor power uprate and the use of pools C and D, will substantially exceed the capability of the present CCW system.

20. To summarize, CP&L's short-term plan (through 2001) for cooling pools C and D is to exploit the margin in the existing CCW system, so as to accommodate an additional heat load of 1.0 million BTU/hour. CP&L's longer-term plan is to upgrade the CCW system, in a manner not yet specified, so as to accommodate an additional heat load of 15.6 million BTU/hour. The CCW upgrade must also accommodate an increase in the rated power of the Harris reactor. Attachment B indicates CP&L's expectation that the design of the CCW upgrade will commence in mid-1999 and will be completed in early 2001, one year after pool C enters service.

21. In order to avoid exceeding the available margin in the existing CCW system while cooling pools C and D, CP&L may be obliged to require its operators to divert some CCW flow from the residual heat removal (RHR) heat exchangers during the recirculation phase of a design-basis loss-of-coolant accident (LOCA) event at the Harris reactor.[9] This raises a safety issue because, during the recirculation phase of a LOCA, operation of the RHR system is essential to keeping the reactor core and containment in a safe condition. Both CP&L and the NRC have identified the proposed additional heat load on the Unit 1 CCW system as an "unreviewed safety question," i.e., a safety question that has not been previously reviewed by the NRC Staff.[10] It should be noted in this context that exploitation of the margin in the existing CCW system may involve changes in design assumptions that include fouling factors and tube plugging limits. See Attachment C. The discussion of CCW capability which is provided in Enclosure 9 of CP&L's license amendment application is insufficient to determine the nature and significance of the assumptions made by CP&L.

22. **Backup diesel generators.** The cooling systems for pools C and D will draw electrical power from the electrical systems of the existing Harris plant. If electricity

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[8] License amendment application, Enclosure 5.

[9] License amendment application, Enclosure 9.

[10] Ibid; Federal Register notice for this application.

supply to the cooling pumps for pools C and D is interrupted, the pools will heat up and eventually boil. CP&L says that pools C and D will begin to boil after a time period "in excess of 13 hours", assuming a bounding decay heat load of 15.6 million BTU/hour.[11] To prevent the onset of pool boiling in the event of a loss of offsite power, the Harris operators may be obliged to provide electrical power to pools C and D from the emergency diesel generators, which also serve pools A and B and the reactor. In the present license amendment application, CP&L does not address the ability of the emergency diesel generators to meet the additional electrical loads associated with pools C and D. CP&L does mention in the Harris FSAR the potential for connecting "portable pumps" to bypass the pool cooling pumps should the latter be inoperable.[12] However, the characteristics, capabilities and availability of such portable pumps are not addressed in the present license amendment application. Meeting the electrical load of pools C and D from the systems of the existing Harris plant is a safety issue because it could increase the probability of design-basis or severe accidents at the Harris reactor or at pools A through C.

23. **Lack of QA documents.** Activation of pools C and D will require the completion of their cooling and water cleanup systems, and the connection of their cooling systems to the existing CCW system. CP&L states that approximately 80% of the necessary piping was completed before the second Harris reactor was cancelled.[13] However, some of the quality assurance documentation for the completed piping is no longer available. Much of the completed piping is embedded in concrete and is therefore difficult or impossible to inspect. To address this situation, CP&L proposes an Alternative Plan to demonstrate that the previously completed piping and other equipment is adequate for its purpose.[14] Nevertheless, the cooling systems for pools C and D will not satisfy ASME code requirements. Attachment D provides supporting information.[15] Failure to satisfy ASME code requirements could increase the probability of design-basis or severe accidents at pools C and D.

G. The Degree of Hazard Posed by Spent Fuel Storage at Harris

24. The NRC and CP&L have performed and published site-specific analyses which provide information about potential severe accidents at the Harris reactor. However, to my knowledge neither NRC nor CP&L has performed any site-specific analysis which

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[11] License amendment application, Enclosure 7, page 5-8.

[12] Harris FSAR, page 9.1.3-4, Amendment No. 48.

[13] License amendment application, Enclosure 1, page 4.

[14] License amendment application, Enclosure 8.

[15] Attachment D is a portion of a set of viewgraphs (titled "10CFR50.55a Alternative Plan") shown by CP&L representatives during a meeting with NRC staff on 16 July 1998.

examines potential severe accidents affecting any of the Harris fuel pools, including pools C and D.

25. The NRC examined severe reactor accidents in its Final Environmental Statement for the Harris plant.[16] Site-specific consequence modelling was performed by the NRC for hypothetical accidents that released as much as 82 percent of the inventory of cesium isotopes in the reactor core. CP&L has submitted to the NRC an Individual Plant Examination (IPE) for the Harris plant.[17] In addition, CP&L has submitted a similar analysis (an IPEEE) for "external" initiating events.[18] The IPE and IPEEE studies examined the potential for severe reactor accidents that could release substantial amounts of radioactivity.

26. In the absence of similar studies for the Harris pools, one must perform scoping calculations to indicate the degree of hazard posed by spent fuel storage at Harris. The degree of hazard is important when one considers the relevance of a safety issue to a determination of "no significant hazards". If preliminary evidence about a safety issue suggests the potential for accidents with either high probability or large consequences, then the NRC staff should not make a determination of "no significant hazards".

27. The radioisotope cesium-137 is one important indicator of the hazard potential posed by a nuclear facility. This isotope has a half-life of 30 years, emits intense gamma radiation, and is released comparatively readily during severe accidents. The 1986 Chernobyl accident released about 90,000 TBq (27 kg) of cesium-137 to the atmosphere, which accounted for most of the offsite radiation exposure attributable to that accident. Official estimates indicate that this exposure will cause 50-100 thousand extra cancer fatalities worldwide over the next 70 years.[19]

28. The core of the Harris reactor contains 157 PWR fuel assemblies. At shutdown, this core contains about 155,000 TBq (47 kg) of cesium-137.[20] When a spent fuel assembly is discharged from the reactor, it will contain more cesium-137 than the average assembly at shutdown. CP&L plans an eventual, aggregate capacity in the Harris pools of 3,080 PWR assemblies and 5,304 BWR assemblies. Note that the cesium-137 content in each BWR assembly will be about one quarter the cesium-137 content in each PWR assembly,

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[16] NRC, Final Environmental Statement related to the operation of Shearon Harris Nuclear Power Plant, Units 1 and 2, NUREG-0972, October 1983.

[17] CP&L, Shearon Harris Nuclear Power Plant, Individual Plant Examination Submittal, Final Report, 31 August 1993.

[18] CP&L, Shearon Harris Nuclear Power Plant Unit No. 1, Individual Plant Examination for External Events Submittal, June 1995.

[19] Allan S Krass, Consequences of the Chernobyl Accident (Cambridge, Massachusetts: Institute for Resource and Security Studies, December 1991).

[20] NRC, Final Environmental Statement, page 5-50.

if both assemblies have been discharged for an equal period.[21] After discharge, the content of cesium-137 in a fuel assembly will decay exponentially with a half-life of 30 years.

29. As a simplified illustration, assume that all fuel assemblies in the Harris pools have been discharged for an equal period. Further assume that all four pools are full and contain 3,080 PWR assemblies and 5,304 BWR assemblies. The pools will then contain as much cesium-137 as 4,406 PWR assemblies. (3,080 + 5,304 x 1/4 = 4,406) Note that 4,406 PWR assemblies represent 28 cores of the Harris reactor.

30. If an accident can be postulated that releases to the environment a significant fraction of the cesium-137 in the Harris pools, then it is clear that the consequences of this accident would be large. The offsite radiation exposure could be an order of magnitude larger than the exposure from the Chernobyl accident. Activation of pools C and D could lead to an accident which creates offsite radiation exposure as much as two times higher than the exposure that would arise from a similar accident involving only pools A and B.

H. Loss of Water from Spent Fuel Pools at Harris

31. Loss of water from one or more of the Harris pools could initiate a release to the environment of a significant fraction of the cesium-137 in the pools. This potential exists because the cladding of PWR or BWR fuel is a zirconium alloy which can react exothermically with air or steam. Thus, if the water in a fuel pool is removed and the fuel is partially or totally uncovered, one must be concerned about the possibility of a runaway air-zirconium or steam-zirconium reaction. Such a reaction could release cesium-137 and other radioisotopes from affected fuel into the fuel building. That building was not designed to contain radioisotopes released during a vigorous exothermic reaction in the pools, and it can be assumed that most of the volatile radioisotopes entering the building from the affected fuel would be released from the building as an atmospheric plume.

32. Several reports prepared by or for the NRC have examined the conditions under which a runaway zirconium reaction might occur.[22] However, these reports have concentrated almost entirely on a postulated condition of instantaneous, complete loss of water from a pool. Such a condition is unrealistic in any scenario which preserves the configuration of the spent fuel racks. If water is lost by drainage or evaporation and no makeup occurs, then complete loss of water will always be preceded by partial

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[21] The ratio of one quarter derives from the parameters shown in the license amendment application, Enclosure 7, page 5-15.

[22] Relevant reports include: V L Sailor et al, Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82, NUREG/CR-4982, July 1987; E D Throm, Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools", NUREG-1353, April 1989; and R J Travis et al, A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants, NUREG/CR-6451, August 1997.

uncovering of the fuel. If makeup is considered, the water level could fall, rise or remain static for long periods.

33. Partial uncovering of the fuel will often be a more severe condition than complete loss of water because, during partial uncovering, convective heat loss is suppressed by the residual water at the base of the fuel assemblies. As a result, longer-discharged fuel with a lower heat output may undergo a runaway steam-zirconium reaction during partial uncovering while it would not undergo a runaway air-zirconium reaction if the pool were instantaneously emptied.

34. I am aware of only one instance in which reports produced by or for the NRC address the hazard posed by partial uncovering, namely in a report prepared for the NRC by Sandia Laboratories and published in 1979.[23] Part of this report did address a situation of partial uncovering, but used a crude heat transfer model and neglected to consider the onset of a steam-zirconium reaction. Nevertheless, the report found (page 76) that ".....an incomplete drainage can potentially cause a more severe heatup problem than a complete drainage, if the residual water remains near the baseplates". A portion of the 1979 Sandia report is provided here as Attachment E. An internal NRC memo mentions the consideration of partial uncovering in the 1979 Sandia report.[24]. Otherwise, it appears that the NRC has ignored the hazard posed by partial uncovering. This hazard was not reflected in the regulatory analysis whereby the NRC purportedly resolved Generic Issue 82.[25]

35. In a situation of falling water level, a fuel assembly might first undergo a runaway steam-zirconium reaction, then switch to an air-zirconium reaction as water falls below the base of the rack and convective air flow is established. In this manner, a runaway air-zirconium reaction could occur in a fuel assembly that is too long-discharged (and therefore produces too little heat) to suffer such a reaction in the event of instantaneous, complete loss of water. Conversely, a rising water level could precipitate a runaway steam-zirconium reaction in a fuel assembly that had previously been completely uncovered but had not necessarily suffered a runaway air-zirconium reaction while in that condition. The latter point is highly significant in the context of emergency measures to recover control of a pool which has experienced water loss. Inappropriate addition of water to a pool could exacerbate the accident.

36. The NRC's failure to consider partial uncovering of fuel should be borne in mind when one reviews NRC-sponsored reports that purport to address the hazard posed by water loss from a fuel pool. This hazard should be re-analyzed through detailed modelling. The modelling should consider both partial and complete uncovering and the

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[23] Allan S Benjamin et al, Spent Fuel Heatup Following Loss of Water During Storage, NUREG/CR-0649, March 1979.

[24] Internal NRC Memorandum from J T Han to M Silberberg, "Response to a NRR request to review SNL studies regarding spent fuel heatup and burning following loss of water in storage pool", 21 May 1984.

[25] E D Throm, op cit.

transition from one of these states to the other. Also, the modelling should cover: (1) thermal radiation, conduction, and steam or air convection; (2) air-zirconium and steam-zirconium reactions; (3) variations along the fuel rod axis; and (4) radial variations within a representative fuel rod, including effects of the pellet-cladding gap. Experiments will probably be required to support and validate the modelling.

37. Until the problem of water loss is re-analyzed in this manner, there is no basis for determining when fuel has been discharged for a sufficiently long period that it will not suffer a runaway zirconium reaction in the event of water loss. If the problem were to be properly analyzed through validated models, such a determination could be made within some margin of error, but the determination should consider site-specific factors. For example, the detailed design of a rack might be an important site-specific factor.

38. No determination of this kind has been made for pools C and D at Harris, nor does the methodology now exist to make such a determination. In any case, there is nothing in the license amendment application and its proposed modifications to the Harris Technical Specifications which prohibits the placing of freshly discharged fuel in pools C and D. Reports previously prepared for the NRC concede that freshly discharged fuel can experience a runaway air-zirconium reaction in the event of complete water loss.

39. A variety of events, alone or in combination, could lead to partial or complete uncovering of spent fuel in the Harris pools. This class of events should be subjected to the kind of systematic analysis that is performed in an IPE and an IPEEE. Relevant events include: (1) an earthquake, cask drop, aircraft crash, human error, equipment failure or sabotage event that leads to direct leakage from the pools; (2) siphoning of water from the pools through accident or malice; (3) interruption of pool cooling, leading to pool boiling and loss of water by evaporation; and (4) loss of water from active pools into adjacent pools or canals that have been gated off and drained. Interactions with the Harris reactor should be considered. For example, a reactor accident might release radioactivity that precludes personnel access to the plant for purposes of maintaining or restoring pool cooling.

I. Increased Probability or Consequences of Accidents Previously Evaluated

40. The Federal Register notice of this license amendment application claims that the probability of a spent fuel assembly drop or a misloaded fuel assembly is not significantly increased if the license amendment is approved and pools C and D are activated. This claim is false, because activation of pools C and D will roughly double the total number of fuel handling operations to be conducted at Harris. Assuming that the general nature of fuel handling operations continues as before, the probability of a fuel assembly drop or misloaded fuel assembly, integrated over the entire period of the Harris operating license, will increase significantly, by a factor of two. This point has been made by David Lochbaum of the Union of Concerned Scientists, in a 22 January 1999 letter to the NRC Commissioners. A copy of his letter is provided here as Attachment F. If probability is integrated over the remaining period of the Harris operating license, rather than over its total duration, then activation of pools C and D will more than double the probability of a fuel assembly drop or a misloaded fuel assembly.

41. A spent fuel assembly drop or a misloaded fuel assembly are members of a broader class of accidents that could arise during the movement of fuel from other CP&L stations to Harris, and during fuel movement within Harris. This class of accidents will include design-basis accidents and severe accidents. Assuming that the general nature of fuel movement continues as before, the probability of accidents in this class, integrated over the entire period of the Harris operating license, will double if pools C and D are activated. If integrated over the remaining period of the operating license, the probability will more than double.

42. The PWR racks in pools C and D will be safe against criticality for a comparatively narrow range of fuel enrichment and burnup. Thus, assuming that the general nature of fuel movement continues as before, the probability of a criticality accident will be significantly increased if pools C and D are activated. This probability will increase on a per-movement basis, so it will more than double when integrated over the entire period of the Harris operating license. The consequences of a criticality accident may also be significantly increased.

43. Activation of pools C and D will add to the electrical load and CCW heat load of existing Harris systems. It will also add to the burden of work on the Harris operators. These effects will increase the probability of two categories of design-basis or severe accidents. First, they will significantly increase the probability of accidents associated with the Harris reactor, because the reactor's CCW and electrical systems and its operators will be under greater stress. Second, they will significantly increase the probability of accidents at the Harris pools that are attributable to interruptions in cooling and electricity supply and to increased operator stress. Also, the inability of cooling piping at pools C and D to meet ASME code requirements could significantly increase the probability of design-basis or severe accidents at these pools.

44. As mentioned in paragraph 24 above, to my knowledge there has been no site-specific analysis of severe accidents affecting any of the Harris pools. To the extent that such accidents have been previously evaluated, their consequences will be significantly increased by the activation of pools C and D. The fuel storage capacity of these pools will roughly double the storage capacity at Harris, creating the potential for a doubled inventory of radioactivity. Severe accidents could affect some or all of the Harris pools. As I have discussed in paragraph 30 above, the potential doubling of radioactivity in the pools could significantly increase the consequences of severe accidents.

J. Possibility of New or Different Kinds of Accident from any Accident Previously Evaluated

45. To my knowledge, there has been no site-specific evaluation of the probability or consequences of severe accidents at pools A and B at Harris. A variety of severe accidents are possible and should be subjected to the kind of systematic analysis that is performed in an IPE and IPEEE. The NRC has performed evaluations of accidents involving loss of water from fuel pools, generically and for sites other than Harris.

However, these evaluations are seriously deficient because they failed to consider partial uncovering of fuel. To summarize, at pools A and B there exists the possibility of new or different kinds of accident from any accident previously evaluated. The same possibility will exist at pools C and D if these are activated.

46. Provision of electrical power, including power from emergency diesel generators, and CCW service from the existing Harris plant to pools C and D could introduce the potential for design-basis or severe accidents that are new or different from any accident previously considered. The IPE and IPEEE studies performed for Harris did not address the provision of electrical power and CCW service to pools C and D. As an example of the potential for new or different accidents, the need to provide cooling to pools C and D will place increased stress on the CCW system, the emergency diesel generators, and the plant operators during a design-basis LOCA.

47. Severe accidents at some or all of the Harris pools could lead to offsite radiation exposure an order of magnitude larger than the exposure from the Chernobyl accident. Activation of pools C and D could significantly increase both the probability and consequences of such accidents. Thus, CP&L's proposed license amendment poses a "significant hazard" by any reasonable definition of that term.

J. Significant Reductions in Margins of Safety.

48. Activation of pools C and D will create an additional heat load on the existing CCW system. CP&L proposes to meet this load in the short term by exploiting the margin in the CCW system. In my professional opinion, the reduction in the CCW safety margin caused by the increased heat load is significant. Both the NRC and CP&L have also recognized that increasing the heat load on the CCW system constitutes an unreviewed safety question. The safety margin will be especially reduced if, during a LOCA, the operators must divert water from the RHR to the spent fuel pools. This will increase stress on the operators and create opportunities for human error.

49. As pools C and D become filled and the reactor receives a power uprate, the load on the CCW system will increase further. CP&L offers no assurance that the present margin of safety will be restored by upgrading the CCW system to accommodate these burdens.

50. CP&L proposes to activate pools C and D using cooling systems that will not satisfy ASME code requirements. This action could potentially cause a significant reduction in margins of safety for pool cooling. CP&L's Alternative Plan has not been subjected to any public scrutiny or rigorous review. It deserves, at the least, thorough consideration at a licensing hearing before the license amendment is issued.

51. CP&L proposes to provide electrical service to pools C and D from the existing (Unit 1) electrical system at Harris, having rejected the option of dedicated emergency diesel generators to serve pools C and D. The existing diesel generators already serve the safety systems in Unit 1 and spent fuel storage pools A and B. By adding pools C and D to the load carried by the Unit 1 diesel generators, CP&L would add stress on the diesel generators and on the plant operators. In the event of a loss of offsite power, these effects could significantly reduce the margin of safety at the Harris reactor and the fuel pools.

L. Environmental Review

52. As discussed above, the original design of the Shearon Harris plant called for cooling of spent fuel pools C and D by the Unit 2 CCW system. The FEIS for the operating license presumably based its conclusions on this design. I have seen no analysis by the NRC Staff, either in the 1983 FEIS or in a subsequent Environmental Impact Statement or Environmental Assessment, of the environmental impacts of altering the Shearon Harris design to provide for cooling of pools C and D by the Unit 1 CCW system.

M. Conclusions

53. From the preliminary evidence presented by the NRC and CP&L, I conclude that operation of the Shearon Harris plant in accordance with the license amendment proposed by CP&L will violate all three of the NRC's conditions for a determination of "no significant hazards." Therefore, the NRC staff should reverse its position and should determine that CP&L's license amendment request does <u>not</u> involve no significant hazards consideration.

54. The proposed license amendment raises serious safety concerns which deserve prior consideration at a licensing hearing.

****

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

Executed on 12 February 1999.

G. R. Thompson

Gordon Thompson

ATTACHMENT A

INSTITUTE FOR RESOURCE AND SECURITY STUDIES

Curriculum Vitae:
GORDON R. THOMPSON

December 1996

Professional expertise

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

Education

- Ph.D. 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)

- Environmental School, Clark University, Worcester, MA, 1996: session leader at the Summer Institute, "Local Perspectives on a Global Environment".
- Nuclear Free Local Authorities, UK, 1996: review of the safety of high level radioactive waste storage at the Sellafield complex.
- 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)

- *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, Version 1.0,* 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 for the 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)

- 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.

Contact information

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ATTACHMENT B

Harris Spent Fuel Pool 'C' and 'D' Activation

Project Update

July 16, 1998

CP&L

001659

Background

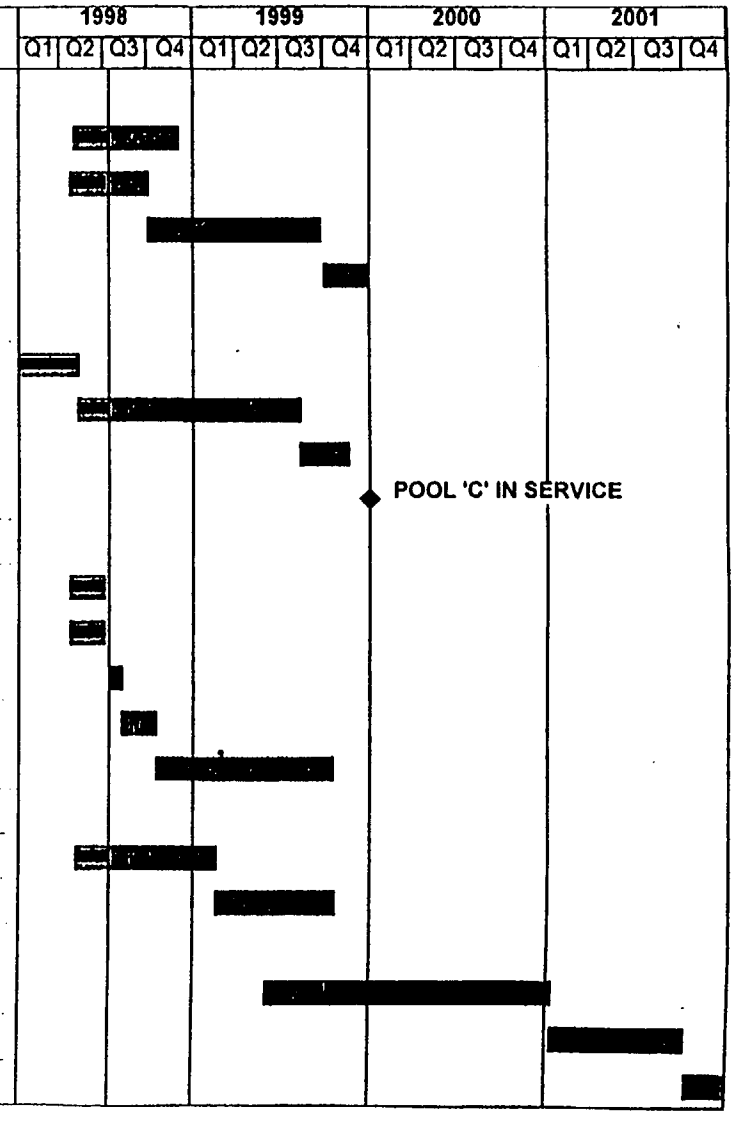
- Original HNP Design
  - Four (4) nuclear units; four (4) fuel pools; two (2) cooling systems
  - Pools 'A' and 'B' to support Units 1 and 4
  - Pools 'C' and 'D' to support Units 2 and 3
  - A separate, fully-redundant, 100% capacity cooling and cleanup system for each set of pools
    - Pool 'C' and 'D' cooling system to be supported by Unit 2 CCW and Unit 2 electrical systems

Background (Continued)

- Units 2, 3 and 4 canceled in early 1980's,
  - All four pools completed
  - Pools 'A' and 'B' placed in service to support HNP Unit 1 and spent fuel shipping from BNP and RNP
  - Cooling system for pools 'C' and 'D' was not completed
    - Construction stopped when unit 2 canceled in 1983
- Plan at time of Unit 1 license was to complete cooling system and place pools 'C' and 'D' in service when necessary
- Fuel Pool 'C' is needed in early 2000 to support spent fuel shipping requirements from BNP and RNP

Schedule

ID	PROJECT	Task Name
1	PHASE 1 COOLING	
2		SFPC DESIGN
3		CCW DESIGN
4		INSTALLATION
5		SYS TEST
6	RACKS	
7		DESIGN/ANALYSIS
8		RACK FABRICATION
9		INSTALL RACKS
10		POOL 'C' IN SERVICE
11	LICENSING	
12		50.55A
13		T.S. CHANGE
14		NRC MEETING
15		REVISE SUBMITTAL/CCW USQ
16		NRC REVIEW/APPROVE
17	SUPPORT PROJECTS	
18		DESIGN
19		INSTALLATION
21	PHASE 2- CCW UPGRADE	
22		DESIGN
23		INSTALLATION
24		OUTAGE TIE-INS



ATTACHMENT C

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 11, 1998

LICENSEE: CAROLINA POWER AND LIGHT COMPANY

PLANT: SHEARON HARRIS, UNIT 1

SUBJECT: SUMMARY OF MEETING WITH THE CAROLINA POWER AND LIGHT COMPANY (CP&L)

On March 3, 1998, the staff met with representatives of Carolina Power & Light Company (CP&L) to discuss the Shearon Harris Nuclear Power Plant (SHNPP) 'C' and 'D' spent fuel pools activation project. Enclosure 1 is a list of meeting attendees. Enclosure 2 is a copy of the handout provided at the meeting. The CP&L presentation included background information, a discussion of licensing activities, and the project schedule.

Background

Originally, SHNPP was intended to be a four unit site with four fuel pools (A,B,C, and D) and two Fuel Pool Cooling and Cleanup systems (FPCCS). Although three of the four units were canceled, the construction of all four pools and one of the FPCCS was completed. Also, a portion of the piping for the other FPCCS was installed. Currently pools 'A' and 'B' are in service and not only store SHNPP fuel, but also store spent fuel from other CP&L plants (Brunswick Units 1& 2, and Robinson). Pools 'C' and 'D' are not in service.

CP&L has determined that pools 'C' and 'D' will be needed to ensure all four units maintain a prudent operating reserve for core off loads. According to CP&L, pool 'C' is needed by early 2000 to support fuel shipments from Brunswick and Robinson. In order to place pools 'C' and 'D' in service, the FPCCS and pool racking must be completed for pools 'C' and 'D'.

Licensing Activities

CP&L identified three licensing activities associated with the completion of pools 'C' and 'D'. The first is a potential unreviewed safety question (USQ) associated with the modification of the Unit 1 Component Cooling Water (CCW) System. Although the Unit 1 CCW system was not originally designed to cool the FPCCS for pools 'C' and 'D', CP&L has determined that the Unit 1 CCW system has sufficient margin to accept the 'C' and 'D' FPCCS load. The original design was for the Unit 1 CCW to cool the FPCCS for pools 'A' and 'B', and for the Unit 2 CCW system to cool the FPCCS for pools 'C' and 'D'. The staff asked several questions about the spent fuel pool, the FPCCS, and CCW system designs. The staff also inquired about SHNPP fuel handling practices.

The second licensing activity discussed involved piping certification for the 'C' and 'D' FPCCS. A portion of the piping for the 'C' and 'D' FPCCS is already installed, with some embedded in concrete, making approximately 14 field welds inaccessible. CP&L inadvertently disposed of the piping certification records for the installed piping, which makes it unable to demonstrate that the piping satisfies the design requirements of American Society of Mechanical Engineers (ASME) Code Section III. CP&L stated that it intends to request relief from ASME Code Section III. The staff stated that a relief request from the requirements of ASME Code

Section III would not be appropriate. The staff recommended that CP&L propose an alternative method, as allowed by 10 CFR 50.55a, that provides an acceptable level of safety and quality. CP&L agreed with the staff's comments and stated that a relief request was not the appropriate terminology for its request. CP&L stated that it intends to propose a piping certification plan, which includes tests and inspections, as an alternative method to the requirements of ASME Code Section III.

CP&L also intends to submit a Technical Specification (TS) change for high density racks in pools 'C' and 'D'. The TS change would modify SHNPP spent fuel capacity.

Schedule

CP&L stated that the TS change and the piping certification plan will be ready for submittal this summer, and the CCW USQ will be ready by fall. Due to the complex nature of this review, the staff recommended that CP&L make one complete submittal that includes all three licensing activities as oppose to three separate submittals. The staff also recommended that CP&L may want to meet with the staff again in the summer to discuss, in more detail, the TS change and the piping certification plan.

CP&L agreed with the staff's recommendations, and intends to submit one amendment encompassing all three licensing activities in the fall. CP&L stated that approval is needed by the end of 1999.

Scott C. Flanders, Project Manager
Project Directorate II-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-400

cc w/enclosures:
See next page

HNP Spent Fuel Pool 'C' and 'D' Activation

Project Status

March 3, 1998

CP&L

Enclosure 2

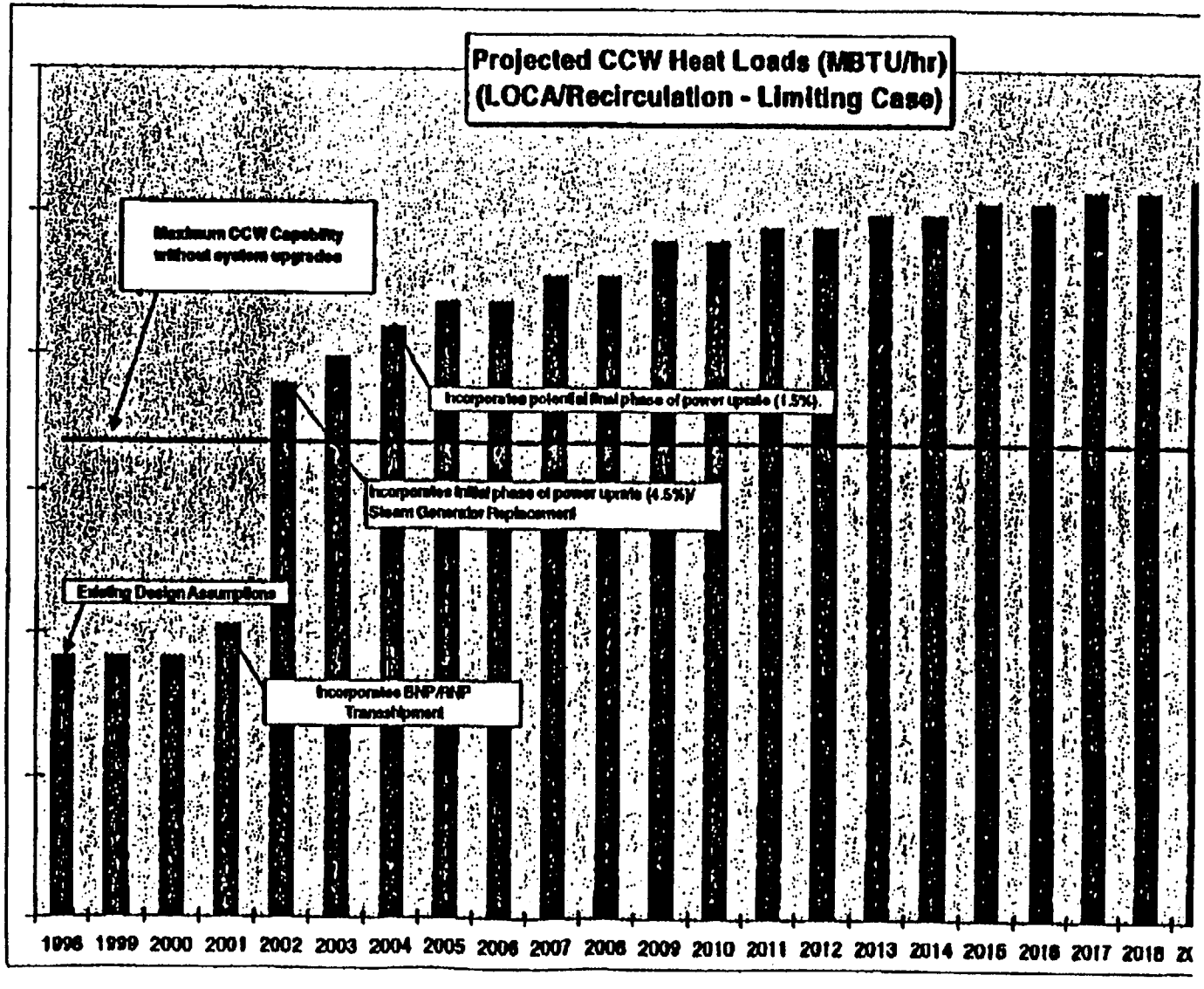
SFP Cooling Options Considered

- Independent Cooling
  - With and without dedicated emergency diesel generators
- Unit 1 Component Cooling Water (CCW)
  - 'As Is' (current design assumptions)
  - CCW with some changes in design assumptions (fouling factors, tube plugging limits, flow rates, IST limits, etc.)
  - CCW with system modifications to improve thermal-hydraulic performance
- Dry storage facilities instead of pools 'C' and 'D'

Cooling System Completion

- Use CCW to provide cooling to fuel pool cooling
  - Phase 1 - Complete fuel pool cooling loop work and tie-ins to CCW (1998-1999)
    - Existing system adequate for near-term operation until power uprate is implemented
  - Phase 2 - Perform CCW system upgrade concurrent with power uprate (1999 - 2001)
    - Final scoping and detailed design/implementation to occur after sufficient power uprate analysis has been completed

Projected CCW Heat Loads



001668

10CFR50.55a Alternative Plan

Project Update
July 16, 1998

CP&L

001669

ATTACHMENT D

Spent Fuel Storage Facilities - Current Configuration

- Fuel Handling Building completed
  - Embedded piping installed, inspected and tested
  - HVAC system completed
- Unit 1 (South) A and B Spent Fuel Pools and supporting systems completed, operating
- Unit 2 (North) C and D Spent Fuel Pools installed, but supporting systems not completed
  - Spent Fuel Pool Cooling major equipment installed
  - Majority of Spent Fuel Pool Cooling System piping installed
  - Significant portion of CCW piping in Fuel Handling Building installed; but no Unit 2 CCW and RWST available

Completing North Spent Fuel Pool Facilities - ASME Code Compliance

- Partially completed systems were never issued a Partial Data Report
  - No partial N stamp on completed portion of construction
  - Original N Certificate Program no longer maintained
- Field installation records for piping discarded
  - Records purged during document control cleanup effort
  - Includes Code required records for weldments

Conclusion

- Cannot satisfy ASME code requirements in completing North Spent Fuel Pools Cooling Systems using originally constructed portion of piping
- "Alternative Plan" per 10CFR50.55a(3) necessary for completion of construction
  - Requires demonstration of "acceptable level of quality and safety" or hardship without compensating increase in quality and safety

ATTACHMENT E

NUREG/CR-0649
SAND77-1371
R-3

SPENT FUEL HEATUP FOLLOWING LOSS OF WATER DURING STORAGE

Allan S. Benjamin
David J. McCloskey
Dana A. Powers
Stephen A. Dupree

Date Published: March 1979

Sandia Laboratories
Albuquerque, New Mexico 87185
operated by
Sandia Corporation
for the
U.S. Department of Energy

Prepared for
U.S. Nuclear Regulatory Commission
Washington, DC 20555
Under Interagency Agreement DOE 40-550-75
NRC FIN No. A2050

5. OTHER CONSIDERATIONS

5.1 Effect of Incomplete Drainage

Many spent fuel holder designs provide only a single inlet hole for convective flow through each fuel element, located in the baseplate or near the bottom of the holder. If there is a complete pool drainage, the air must circulate down and under the fuel elements before passing through the baseplate inlet hole into the fuel assembly. An incomplete drainage could block this flow and reduce the effectiveness of natural convective cooling. Open frame configurations are, of course, exempt from this possibility because the flow does not have to pass through an inlet hole in order to gain proximity to the fuel element.

A detailed analysis of spent fuel heatup in the event of an incomplete drainage has not been undertaken. However, an approximate analysis has been performed to estimate the amount of aggravation that might occur if the water ceased to drain after exposing all but the bottom portion of the fuel elements. The analysis is included in Appendix B and is based, among other things, upon upper and lower bound estimates of the thermal radiation absorbed by the water from the hot fuel rods above. The temperature distribution along the rods is prescribed in this analysis according to estimates made of the likely distribution that would occur just prior to the onset of self-sustaining clad oxidation. The amount of heat produced above the water level is then determined together with the amount that could be removed by various mechanisms, including water boiling (latent heat), convection to the steam produced

Table VIII.

Estimates of Heat Removal Capability in an Incompletely Drained Pool, One Year Decay Time*

1. Normalized water level (z_w/L)	0.0	0.1	0.2
2. Heat transferred to water, per assembly (KW):			
a. by decay heat	0.0	0.2	0.6
b. by thermal radiation from above	0.3 - 1.3	1.2 - 2.6	3.0 - 4.3
c. total	0.3 - 1.3	1.4 - 2.8	3.6 - 4.9
3. Time to start boiling (hours)	1.0 - 4.3	0.9 - 1.8	0.7 - 1.0
4. Water surface recession rate (cm/hr)	0.7 - 3.2	3.5 - 7.0	9.0 -12.2
5. Decay heat produced by spent fuel above water level, per assembly (KW)	5.1	4.9	4.5
6. Removal of heat produced by spent fuel above water level, per assembly (KW):			
a. by radiation to water	0.3 - 1.3	1.2 - 2.6	3.0 - 4.3
b. by radiation to building	0.0 - 0.9	0.0 - 0.9	0.0 - 0.9
c. by transfer to water vapor	0.2 - 0.8	0.9 - 1.8	2.3 - 3.1
d. by transfer to air	0.4	0.4	0.4
e. total	0.9 - 3.4	2.5 - 5.7	5.7 - 8.7
7. Heat removal surplus (deficit) per assembly (KW), line 6e minus line 5.	(4.2)-(1.7)	(2.4)-0.8	1.2 - 4.2

* PWR spent fuel in cylindrical baskets. One year decay time assumed, uniformly throughout pool. Numerical ranges (e.g., 0.3 - 1.3) give lower and upper-bound estimates. See Appendix B.

fact, if the water were to recede below the level where the lower 10% of the rods is still immersed.

A comparison of the peak clad temperature rise versus time for PWR spent fuel with a 1-year minimum decay time in a well-ventilated room is shown in Figure 26. The temperature rise corresponding to an incomplete drainage down to the bottom of the rods, calculated by utilizing the lower-bound radiation estimate, is compared with previous cases for a complete drainage with varying baseplate hole sizes. The clad oxidation effect has not been calculated for the case of incomplete drainage (blocked inlets), because it is believed to be substantially reduced by the unavailability of oxygen within the assembly. Clearly, a 1-year minimum decay time is not sufficient to preclude overheating for this case.

The approximate method used for bracketing the thermal radiation downward to the water and upward to the building is not considered to be precise enough to allow prediction of the minimum allowable decay time in the event of an incomplete drainage. This problem could be approached by formulating a detailed thermal radiation model to calculate shape factors and include the shadowing of radiating surfaces by fuel rods and tie plates. By incorporating this radiation capability into the overall heat transfer models described in Sections 3.3 and 3.4, a credible prediction of the minimum allowable decay time could be obtained. No attempt to do this, however, has been made.

It is clear, however, that an incomplete drainage can potentially cause a more severe heatup problem than a complete drainage, if the residual water level remains near the baseplates. From a practical point of view, it might be possible to make provisions for either completing the drainage or refilling the pool, if this should happen. However, it would

001676

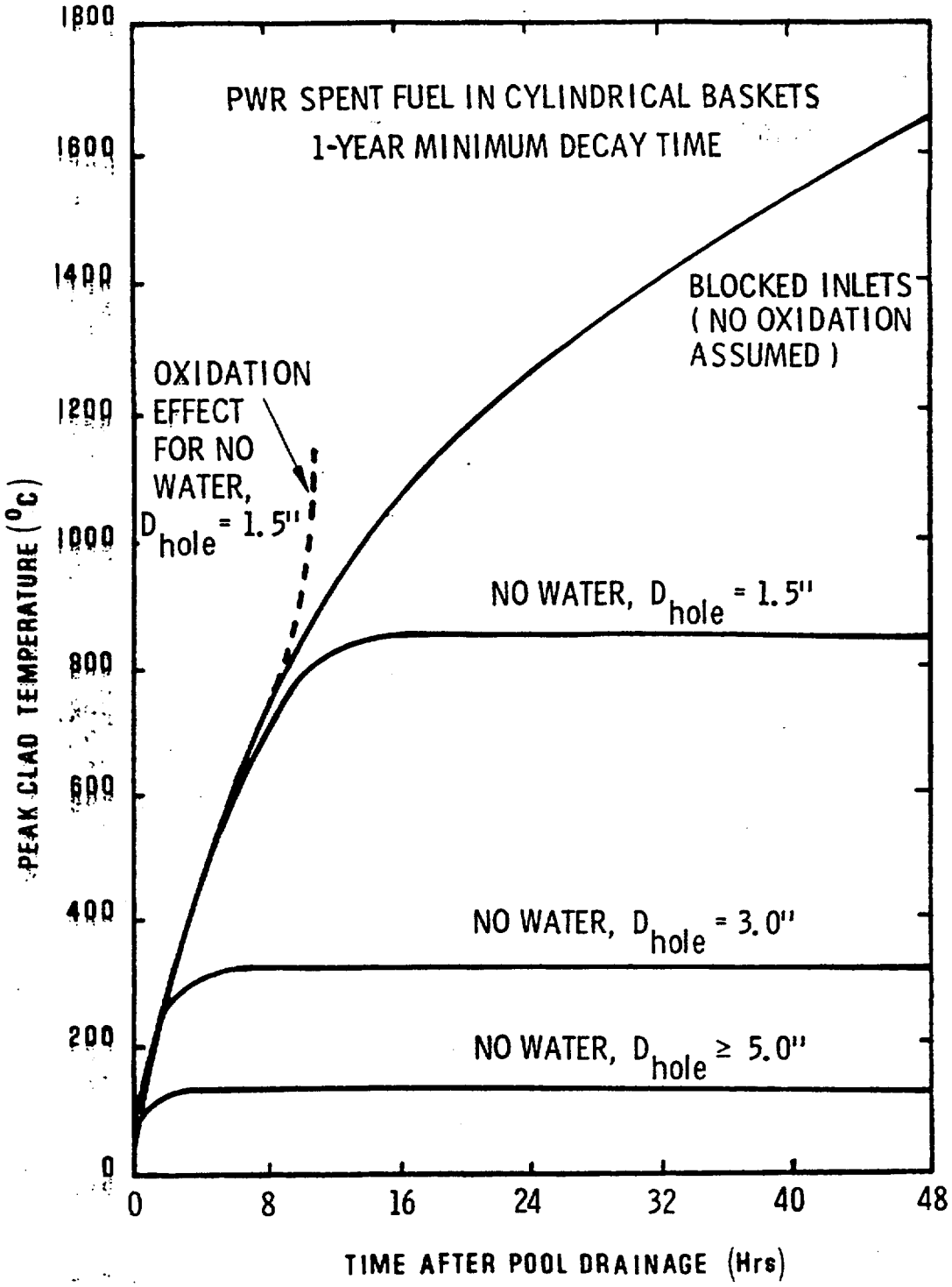


Figure 26. Estimated Heatup of PWR Spent Fuel With Residual Water Sufficient to Block Flow Inlets, Well-Ventilated Room

seem that the special problems associated with an incomplete drainage could best be circumvented by modifying the spent fuel holders to include inlet holes at various elevations along the vertical, rather than just at the baseplate level. According to the predictions, these inlet holes would only be required for the bottom 20 percent of the fuel rod length if the spent fuel were at least a year old. With these additional inlets, the beneficial effect of natural convection would not be cancelled by an incomplete drainage.

5.2 Effect of Surface Crud

Iron oxides are known to deposit upon the outside of the fuel pins during normal operation of the reactor, and these deposits are likely to remain on the fuel pins during storage of the spent fuel. Typically, the iron oxide crud buildup on BWR fuel pins is on the order of 25 to 100 microns and in the form of Fe_2O_3, whereas the buildup on PWR pins is on the order of only 1 to 5 microns and in the form of Fe_3O_4.[16] A calculation was made to determine whether a 100 micron Fe_2O_3 coating on the BWR fuel pins would affect the heatup of these pins during a pool drainage accident, and it was found that the overall effect on the fuel pin temperature was less than one degree.

The question was also raised as to whether some of the crud, which would be contaminated, could be levitated by the air flows produced by natural convection after a pool drainage and thereby produce a health hazard. An analysis of the weight and drag characteristics of iron oxide particles revealed that a BWR fuel assembly having a decay time of 90 days prior to loss of water can produce upward air currents sufficient to levitate a 200-micron sized particle, whereas an assembly allowed to decay for 250 days can levitate a 175-micron sized particle. Since any spallation of the crud would produce particles of roughly the same size as the thickness of the

001678

UNION OF CONCERNED SCIENTISTS

ATTACHMENT F

January 22, 1999

Chairman Shirley A. Jackson
Commissioner Nils J. Diaz
Commissioner Greta J. Dicus
Commissioner Edward McGaffigan, Jr.
Commissioner Jeffrey S. Merrifield
United States Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: CURRENT EXAMPLE OF RISK-DEFORMED REGULATION

Dear Chairman and Commissioners:

During the January 11th Commission briefing on risk-informed regulation and during the January 20th briefing on the proposed reactor oversight process, I expressed our concern that the NRC and the nuclear industry are making risk decisions using incomplete and inaccurate data. As a current example, I call your attention to the license amendment application dated December 23, 1998, by the Carolina Power & Light Company involving spent fuel storage at the Harris Nuclear Power Plant and the subsequent proposed no significant hazards consideration determination (*Federal Register*: January 13, 1999, Vol. 64, No. 8) prepared by the NRC staff.

The licensee and the NRC staff have improperly downplayed the risk associated with the proposed activity. Their risk characterization is wrong. The licensee should be required to resubmit a corrected application and another *Federal Register* notice issued with a corrected proposed no significant hazards consideration determination.

The error involves the determination made by the licensee and endorsed by the staff regarding the affect of the proposed activity, namely placing storage racks in Spent Fuel Pools 'C' and 'D' at the Harris plant, on the probability of a fuel handling accident. From the *Federal Register* notice:

> "The probability that any of the accidents in the above list [a spent fuel assembly drop in a spent fuel pool / loss of spent fuel pool cooling flow / a seismic event / misloaded fuel assembly] can occur is not significantly affected by the activity itself. ... The probabilities of accidental fuel assembly drops or misloadings are primarily influenced by the methods used to lift and move these loads. The method of handling loads during normal plant operations is not signficantly changed, since the same equipment (i.e., Spent Fuel Handling Machine and tools) and procedures as those in current use in pools 'A' and 'B' will be used in pools 'C' and 'D.' Since the methods used to move loads during normal operations remain nearly the same as those used previously, there is no significant increase in the probability of an accident."

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It is precisely this type of "smoke and mirrors" shenanigans that we decried during the briefings. The logic seems proper at face value, but it does not take much effort to show that it is wrong. In Enclosure 1 to the license amendment submittal, the licensee reported that the total storage capacity of pools 'A' and 'B' is 3,669 assemblies and that the proposed activity will add 4,715 storage locations in pools 'C' and 'D.' Thus, if the amendment is granted, CP&L will handle – pick up and move – about twice as many irradiated fuel assemblies as they will if the amendment is not granted.

Consider for a moment the old game of Russian roulette using a six-chamber revolver loaded with a single bullet. CP&L and the NRC staff would apparently conclude that the probability of losing the game are not increased whether one or two turns are taken because, after all, the same method and the same equipment are used each turn. Their logic is simply wrong. The probability of a fuel handling accident at Harris will nearly ***double*** if the license amendment request is granted. This material fact contradicts the conclusion of the licensee and the staff that there will be "no significant increase in the probability," unless doubling the risk is not significant.

Luckily, there's an opportunity to fix the mistake this time. Unfortunately, it's not the first, and probably won't be the last, time this mistake is made. The NRC staff made this same mistake in April 1998 when it allowed the Paducah facility to continue operating with its risk doubled.

We have no intention at this time of formally intervening in this Harris licensing action. We trust that the NRC staff will take the necessary steps to have the licensee fix the fundamental flaw in the licensing amendment request before granting it.

Sincerely,

David A. Lochbaum
Nuclear Safety Engineer

January 31, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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 ADMISSION OF LATE-FILED ENVIRONMENTAL CONTENTIONS

I. INTRODUCTION

Pursuant to the 10 C.F.R. § 2.714(a)(1), Orange County hereby files four environmental contentions which challenge the adequacy of the Nuclear Regulatory Commission ("NRC") Staff's Environmental Assessment ("EA"), which the Staff issued on December 15, 1999. The EA was issued in support of an operating license amendment application submitted by Carolina Power & Light Co. ("CP&L"), which seeks leave for expansion of spent fuel pool storage capacity at the Shearon Harris nuclear power plant.

The contentions are supported by the Declaration of Dr. Gordon Thompson (January 31, 2000) ("Thompson Declaration") which is attached as Exhibit 1.

II. CONTENTIONS

Contention EC-1

In the Environmental Assessment ("EA") for CP&L's December 23, 1998, license amendment application, the NRC Staff concludes that the proposed expansion of spent fuel storage capacity at the Shearon Harris nuclear power plant will not have a significant

effect on the quality of the human environment. Environmental Assessment and Finding of No Significant Impact Related to Expanding the Spent Fuel Pool Stage Capacity at the Shearon Harris Nuclear Power Plant (TAC No. MA4432) at 10 (December 15, 2000). Therefore, the Staff has decided not to prepare an Environmental Impact Statement ("EIS") for the proposed license amendment. The Staff's decision not to prepare an EIS violates the National Environmental Policy Act ("NEPA") and NRC's implementing regulations, because the Finding of No Significant Impact ("FONSI") is erroneous and arbitrary and capricious. In fact, the proposed expansion of spent fuel pool storage capacity at Harris would create accident risks that are significantly in excess of the risks identified in the EA, and significantly in excess of accident risks previously evaluated by the NRC Staff in the EIS for the Harris operating license. These accident risks would significantly affect the quality of the human environment, and therefore must be addressed in an EIS.

There are two respects in which the proposed license amendment would significantly increase the risk of an accident at Harris:

(1) CP&L proposes several substantial changes in the physical characteristics and mode of operation of the Harris plant. The effects of these changes on the accident risk posed by the Harris plant have not been accounted for in the Staff's EA. The changes would significantly increase, above present levels, the probability and consequences of potential accidents at the Harris plant.

(2) During the period since the publication in 1979 of NUREG-0575, the NRC's Generic Environmental Impact Statement ("GEIS") on spent fuel storage[1], new information has become available regarding the risks of storing spent fuel in pools. This information shows that the proposed license amendment would significantly increase the probability and consequences of potential accidents at the Harris plant, above the levels indicated in the GEIS, the 1983 EIS for the Harris operating license, and the EA. The new information is not addressed in the EA or the 1983 EIS for the Harris operating license.

Accordingly, the Staff must prepare an EIS that fully considers the environmental impacts of the proposed license amendment, including its effects on the probability and consequences of accidents at the Harris plant. As required by NEPA and Commission policy, the EIS should also examine the costs and benefits of the proposed action in comparison to various alternatives, including Severe Accident Mitigation Design Alternatives ("SAMDAs")and the alternative of dry storage.

Basis:

A. Regulatory Requirements

NEPA requires federal agencies to prepare an EIS before undertaking any major federal action which may significantly affect the quality of the human environment. 42 U.S.C. § 4332(C). The NRC's implementing regulations at 10 C.F.R. § 51.20(a) also require the NRC to prepare an EIS for any licensing or regulatory action which "is a major Federal action significantly affecting the quality of the human environment."

1 NUREG-0575, Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel (August 1979) (hereinafter "GEIS").

Where aspects of the proposed action are addressed by a previously prepared EIS, a new EIS must be issued if there remains "major federal action" to occur, and if there is new information showing that the remaining action will affect the quality of the human environment "in a significant manner or to a significant extent not already considered." *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 374 (1989). *See also* 10 C.F.R. § 51.92(a), which requires supplementation where the proposed action has not been completed, if: "(1) there are substantial changes in the proposed action that are relevant to environmental concerns; or (2) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts." Although § 51.92 technically does not apply here, where the action proposed in the original Shearon Harris EIS has already been taken, the criteria provide applicable guidance for these circumstances.

B. Substantial Changes in Physical Characteristics and Mode of Operation at Harris

If granted, the proposed license amendment would result in substantial changes to the physical characteristics and mode of operation of the Harris nuclear power plant, in two major respects. First, the number of spent fuel assemblies permitted to be stored at the Harris nuclear power plant would be more than doubled, with a corresponding increase in the inventory of radioactive material. In the event of an accident, this change could significantly increase the magnitude of a radioactive release to the environment. *See* Section F, below.

Second, in its license amendment application, CP&L proposes for the first time at Harris to rely on administrative measures rather than physical measures to prevent

criticality in fuel pools C and D. In particular, CP&L proposes to rely on control of burnup levels in the spent fuel assemblies, rather than relying exclusively on separation of fuel assemblies and solid neutron absorbers, as it does under the current operation. Orange County contends that CP&L's reliance on administrative measures for criticality prevention violates the requirements of General Design Criterion ("GDC") 62.[2] Even if the proposed administrative measures are found to be permitted by GDC 62, they constitute a significant departure from the measures used by CP&L prior to the license amendment, and they are also distinct from the physical criticality prevention measures that were previously evaluated in the NRC's Generic EIS for spent fuel storage and handling. *See* Section F, below.

C. Increment of Accident Risk Posed by Proposed License Amendment

In order to evaluate the need for a new or supplemental EIS in this proceeding, it is necessary to determine the extent to which the proposed amendment would create an additional or incremental risk of accidents. This requires a comparison of the risk posed by the existing operation with the risk posed by the proposed changes to the existing operation, *i.e.*, the activation of fuel storage pools C and D.[3] It is also necessary to evaluate previous environmental analyses of the existing operation, and determine whether they are adequate to address the incremental risk posed by the proposed license amendment.

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2 *See* Orange County's Detailed Summary of Facts, Data, and Arguments and Sworn Submission . . . With Respect to Criticality Prevention Issues (Contention TC-2), filed January 4, 2000, which is adopted and incorporated by reference herein.

3 Orange County defines "risk" as the potential for an accident, encompassing both the probability and the consequences of an accident. The County does not assume, as is sometimes done, that risk is the simple product of probability times consequences. The

The accident risk posed by the current operation of Harris can be characterized for the purpose of this analysis as the "baseline" accident risk. The baseline accident risk has two major components: (1) the risk arising from operation of the Harris reactor, and (2) the risk arising from operation of fuel pools A and B.

D. Environmental Evaluations of Existing Operations

The component of the baseline accident risk that arises from operation of the Harris reactor has been evaluated by the NRC Staff and by CP&L. The NRC's evaluation appears in the 1983 EIS prepared in support of the issuance of the operating license for Units 1 and 2.[4] The EIS examined reactor accidents only, and did not evaluate spent fuel pool accidents.

CP&L's evaluation of reactor accidents appears in CP&L's Individual Plant Examination (IPE) submittal of August 1993, and its Individual Plant Examination for External Events submittal of June 1995. Like the EIS, CP&L's IPE's did not evaluate spent fuel pool accidents.

A generic evaluation of spent fuel pool accidents appears in NUREG-0575, the NRC's GEIS for handling and storage of spent fuel. In Sections 4.2.2 and 4.2.3, the GEIS addresses potential accidents, and concludes that: "The underwater storage of aged spent fuels is an operation involving an extremely low risk of a catastrophic release of radioactivity." *Id.* at 4-13. As explained below in Section F, the findings of the GEIS regarding the risk of spent fuel pool accidents are no longer applicable, because new

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relationship between probability and consequences tends to be more complex than that.
4 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).

information, generated following the publication of the GEIS, shows the risks of a severe spent fuel accident during high-density pool storage of spent fuel are significant.

E. Environmental Evaluations of Proposed License Amendment

CP&L has not evaluated the increment of accident risk that would arise from operation of fuel pools C and D at Harris. The NRC Staff purports to have addressed the increment of accident risk in its EA, which concludes that:

> The proposed action will not significantly increase the probability or consequences of accidents, no changes are being made in the types of any effluents that may be released offsite, and there is no significant increase in occupational or public radiation exposure.

Id. at 6.

F. Inadequacy of EA to Evaluate Accident Risk Posed by License Amendment

The EA is incorrect in its evaluation of the increment of accident risk that would arise from operation of pools C and D at Harris, in three respects. First, new information has become available since the publication of the GEIS, showing that the accident risk for high-density pool storage of spent fuel is significant and was not properly evaluated in the GEIS, the 1983 EIS for the Harris operating license, or the EA. Second, the increment of accident risk arising from operation of pools C and D would be significant, by itself and in comparison to the baseline accident risk.[5] This increment of risk arises from the

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5 The new information also demonstrates that the component of the baseline accident risk at Harris arising from the operation of pools A and B has not been evaluated properly and is greater than represented in the GEIS or the 1983 EIS for Harris. As discussed in contention EC-2 below, the inadequacy of previous environmental analyses has implications regarding the cumulative impacts of the proposed license amendment. The focus of the instant contention, however, is the increment of risk posed by operation of pools C and D. The significance of that increment can be determined solely from the

proposed changes in the physical characteristics and mode of operation of the Harris plant, specifically the greatly increased inventory of spent fuel permitted at the Harris site and the significant weakening of criticality prevention measures. Third, the NRC Staff has not taken into account new information regarding the significant risk posed by sabotage.

1. New Information Shows Higher Accident Risk Than Previously Evaluated

New information, developed after the publication of the GEIS, shows that total or partial loss of water from a fuel pool containing high-density racks can initiate an exothermic reaction of fuel cladding, either an air-zirconium reaction or a steam-zirconium reaction. Once initiated, this reaction could spread to nearby, previously uninvolved, fuel assemblies. A significant fraction of the pool's inventory of radioactive isotopes, notably cesium-137, could be released to the atmosphere and would then travel downwind as a plume, causing extensive land contamination. The new information also shows that total or partial loss of water from a fuel pool is not a remote or speculative event. For example, a degraded-core accident at the Harris reactor, with containment failure or bypass, would almost certainly lead to interruption of cooling of the Harris fuel pools, followed by loss of water from the pools through evaporation. Restoration of

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proposed configuration of pools C and D, and the relationship of pools C and D to the Harris reactor. If an adequate evaluation of the risk posed by pools A and B became available, this evaluation would shed light on the cumulative impacts of the proposed license amendment, but would not affect the significance of the increment of risk that would arise from that amendment.

cooling water or makeup of water lost by evaporation would be precluded because onsite radiation levels would prevent access by personnel.[6]

The new information is summarized in a report by Dr. Gordon Thompson, entitled "Risks and Alternative Options Associated With Spent Fuel Storage at the Shearon Harris Nuclear Power Plant" (February 1999). A copy is attached as Exhibit 2. Dr. Thompson's report summarizes the state of knowledge about fuel pool accidents involving water loss and exothermic reaction of cladding, both generically and in the context of the Harris plant. The report shows that an accident of this type at the Harris plant could contaminate land with cesium-137 to the extent that relocation of populations could be required over an area as large as North Carolina.

The NRC Staff's EA does not reflect the present state of knowledge about potential accidents in high-density fuel pools. The EA focuses on structural failure of a fuel pool, leading to total loss of water. EA at 5-6. In support of its limited discussion of that limited issue, the EA cites four NRC reports: NUREG/CR-4982, Severe Accidents in Spent Fuel Pools in Support of Generic Issue 82; NUREG/CR-5176, Seismic Failure and Cask Drop Analysis of the Spent Fuel Pools at Two Representative Nuclear Power Plants; NUREG/CR-5281, Value/Impact Analysis of Accident Preventative and Mitigative Options for Spent Fuel Pools; and NUREG-1353, Regulatory Analysis for the Resolution of Generic Issue 82: Beyond Design Basis Accidents in Spent Fuel Pools. EA at 5-6. The present state of knowledge about fuel pool accidents, however, is not

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6 A degraded-core accident at the Harris reactor is assumed for purposes of offsite emergency response planning, is evaluated in the EIS for the Harris operating license, and, and is evaluated in CP&L's IPE submittal for Harris. These reports, however, do not discuss the effects of a reactor accident on the operation of the fuel pools at Harris.

confined to that accident scenario or the four reports cited by the NRC Staff. For example, as Dr. Thompson shows in his report, drawing upon other literature and his own analyses, the loss of water from the Harris fuel pools is an almost certain outcome of a degraded-core accident, with containment failure or bypass, at the Harris reactor. *See* Thompson Report, Appendix C. The EA does not address this matter. In addition, Dr. Thompson's report draws upon other literature and his own analyses to show that partial loss of water from a pool can be a more severe accident condition than total loss of water. *See* Thompson Report, Appendix D. The EA does not address this issue either. Thus, the EA incorrectly carries forward elements of the outdated understanding of pool accident risk that is reflected in the GEIS.

Although degraded-core reactor accidents previously have been considered for the Harris plant, it does not appear that consideration has ever been given to the potential for a degraded-core reactor accident to cause a severe spent fuel pool accident by precluding personnel access to the plant in order to restore pool cooling and provide water makeup. Moreover, neither CP&L nor the NRC Staff has ever performed an evaluation of severe spent fuel pool accidents at Harris, including fuel heat-up caused by partial uncovering of the fuel. *See* Thompson Report, Appendix D.

Indeed, the NRC Staff has never performed an adequate evaluation of the potential for severe pool accidents at any plant. Since the early 1980's, the EIS's for the licensing of all U.S. nuclear plants have considered the potential for severe accidents. This consideration has been based on the findings of the Reactor Safety Study (WASH-1400). The Reactor Safety Study's consideration of spent fuel pool accidents, and the

NRC's subsequent re-consideration of such accidents, have been summarized by the NRC as follows:

> "The risk of beyond design basis accidents in spent fuel storage pools was examined in WASH-1400. It was concluded that these risks were orders of magnitude below those involving the reactor core because of the simplicity of the spent fuel storage pool design: (1) the coolant is at atmospheric pressure, (2) the spent fuel is always subcritical and the heat source is low, (3) there is no piping which can drain the pool and (4) there are no anticipated operational transients that could interrupt cooling or cause criticality.
>
> The reasons for the re-examination of spent fuel storage pool accidents are twofold. First, spent fuel is being stored instead of reprocessed. This has led to the expansion of onsite fuel storage by means of high density storage racks, which results in a larger inventory of fission products in the pool, a greater heat load on the pool cooling system, and less distance between adjacent fuel assemblies. Second, some laboratory studies have provided evidence of the possibility of fire propagation between assemblies in an air cooled environment. Together, these two reasons provide the basis for an accident scenario which was not previously considered."[7]

Despite this recognition that pool accidents represent a new, credible accident scenario, the NRC Staff has never given pool accidents the level of analysis that has been given to reactor accidents through WASH-1400, NUREG-1150, EIS's, and IPE's. *See* Thompson Report, Appendix B.

A severe pool accident is not a remote and speculative event. Its lower bound of probability is set by the probability of a degraded-core reactor accident with containment failure or bypass, because such an accident would almost certainly lead to a pool accident, as explained above. A degraded-core reactor accident with containment failure or bypass is recognized as a credible event by the NRC for purposes of evaluating environmental impacts in EIS's, as well as requiring emergency planning for the ten and fifty mile

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7 E.D.Throm, NUREG-1353, Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools" at ES-1 (April 1989).

Emergency Planning Zones around nuclear plants. In addition, licensees are obligated to perform IPE's to examine the site-specific potential for accidents of this type.

Thus, the possibility exists of a class of severe pool accident scenarios that have not been previously evaluated or that have been evaluated improperly, either generically or for the Harris site. The potential and nature of this class of accidents could be examined by the use of PRA techniques that have been developed to examine degraded-core reactor accidents.

2. Significant Increment of Accident Risk Posed by License Amendment

The increment of accident risk from operating pools C and D would be significant, by itself and in comparison to the baseline accident risk, for at least three reasons.

a. Increased fuel storage capacity

First, pools C and D would have a capacity of 4,715 fuel assemblies as compared with the capacity of 3,669 fuel assemblies in pools A and B. This would result in a significant increase in the quantity of long-lived radioactive isotopes (*e.g.*, cesium-137) that could be stored at the Harris plant. An accident at pools C and D could release to the atmosphere a substantial fraction of the inventory of cesium-137 and other radioactive isotopes in these pools. *See* Thompson Report, Appendices D and E. Such a release would yield consequences that would be significant in their own right, and would also be significant in comparison to the consequences of accidents at pools A and B and/or the Harris reactor.

b. Higher density storage

Second, the center-to-center distance for PWR fuel in pools C and D would be 9.0 inches instead of the 10.5 inches in pools A and B. Other factors being equal, this reduced distance would increase the propensity of pools C and D, as compared with pools A and B, to experience an exothermic reaction of fuel cladding in the event of partial or total loss of water. Given a loss of water, the conditional probability of an exothermic reaction in pools C and D would be comparable to or greater than the conditional probability of a similar reaction in pools A and B, and would be substantial over a range of pool loading patterns.[8] Moreover, loss of water from the Harris pools would be an almost certain outcome of a degraded-core accident at the Harris reactor with containment failure or bypass, and such an accident dominates the accident consequences profile of the Harris reactor. *See* Thompson Report, Appendix B. It follows that if pools C and D are activated, the probability of a substantial release of radioactive material from these pools would be comparable to the probability of a substantial release from the Harris reactor.[9]

c. Weakening of Criticality Prevention Measures

Third, CP&L proposes to suppress criticality of PWR fuel in pools C and D by employing administrative controls on the burnup of PWR fuel that would be admitted to these pools. For criticality prevention in pools A and B, CP&L currently relies on physical measures, namely separation of fuel assemblies and the use of solid neutron absorbers. CP&L's proposed reliance on administrative controls for criticality prevention

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8 The "conditional" probability of an accident is the probability of the accident if the occurrence of an event that could cause the accident (in this case, a loss of water) is assumed.

constitutes a major and substantial change in CP&L's operation, while also significantly increasing the probability that a criticality accident would occur at the Harris plant.[10]

Moreover, the environmental impacts of the administrative criticality prevention measures proposed by CP&L have not been addressed in the NRC's GEIS for spent fuel storage and handling, which is cited by the Staff at pages 6-7 of the EA. The criticality prevention measures evaluated and approved in the GEIS as having low environmental impacts are radically different from the criticality control measures proposed by CP&L for its operating license amendment. Only two methods of preventing criticality are evaluated in the GEIS: spacing and neutron absorbing materials incorporated into storage racks. *Id.* at 3-5. The GEIS contemplates that spacing of PWR spent fuel assemblies could be safely reduced to about 12 to 14 inches in the absence of solid neutron-absorbing material in the racks, and 11 to 12 inches with the use of such neutron-absorbing materials. *Id.* The GEIS also explicitly states that: "At the present time, licensing credit for the use of soluble neutron absorbers in the storage pool water is not acceptable to the Nuclear Regulatory Commission and to date no known applications have included credit for this method." *Id.* at 3-6. No discussion of credit for burnup is mentioned.

3. Failure to Consider New Information Regarding Sabotage Risks

The large inventory and mode of management of spent fuel at the Harris plant also significantly increase the opportunities for sabotage during transportation, handling, and

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9 The probability of a substantial release from pools C and D would also be comparable to the probability of a substantial release from pools A and B.

10 *See* Orange County's Detailed Summary of Facts, Data, and Arguments and Sworn Submission . . . With Respect to Criticality Prevention Issues (Contention TC-2), filed January 4, 2000. The Summary and its Appendix C (Assessing the Probability and Consequences of Criticality Events in Fuel Pools) are adopted and incorporated by

storage of the spent fuel. While the NRC has previously declared that it is unable to make a meaningful assessment of the risks of sabotage, this declaration was made many years ago. *See Limerick Ecology Action v. NRC,* 869 F.2d 719, 741-42 (3rd Cir. 1989). Events of recent years have demonstrated that sabotage is a reasonably foreseeable and significant threat whose risks must be addressed in an EIS, whether or not those risks can be quantified. These events include the 1983 bombing of the Marine barracks in Beirut; the 1993 bombing of the World Trade Center; the February 1993 intrusion into the Three Mile Island site, in which the intruder crashed his station wagon through the security gate and rammed it under a partly opened door in the turbine building; the 1995 bombing of the Federal Courthouse in Oklahoma City; the plot to bomb the United Nations Building, FBI offices in New York City, the Lincoln Tunnel, the Holland Tunnel, and the George Washington Bridge; the 1995 release of SARIN nerve gas in the Tokyo subway; and the 1998 bombing of the U.S. embassies in Tanzania and Kenya. *See also* Thompson Report at B-4 (mock raids on U.S. nuclear plants have succeeded in at least 14 of 57 instances since 1991).

The fact that the risk of sabotage may not be easily quantifiable is not an excuse for failing to address it in an EIS. As provided in the Council on Environmental Quality's regulations implementing NEPA, 40 C.F.R. § 1502.22, the agency must make an attempt to evaluate reasonably foreseeable significant adverse effects, if the costs of obtaining the information are not exorbitant. Even if the costs of obtaining the information are exorbitant, the agency must acknowledge that the information exists but is unavailable, make a statement of the relevance of the information to the evaluation of impacts in the

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reference herein.

EIS, summarize existing relevant and credible scientific evidence, and provide the agency's evaluation of the impacts based on generally accepted theoretical approaches or research methods. *See also* 10 C.F.R. § 51.71 ("To the extent that there are important qualitative considerations or factors that cannot be quantified, these considerations or factors will be discussed in qualitative terms.").

In considering the environmental impacts of sabotage, it is particularly important to consider SAMDAs which could mitigate the impacts of sabotage. Using dry storage would substantially reduce the vulnerability of the Harris/Brunswick/Robinson spent fuel to acts of sabotage or terrorism. As discussed at page 12 of the Thompson Report, sabotage/terrorism events at a dry storage installation could release only a small fraction of the radioactive material that could be released from the Harris spent fuel pools. It is much easier to drain a spent fuel pool and cause an accident than it is to penetrate and release the radioactive contents of dry casks holding the same amount of spent fuel.

Contention EC-2: EIS Should Consider Cumulative Impacts In Light of New Information

The EA is deficient because it fails to acknowledge or evaluate the significant cumulative environmental risk posed by the operation of pools A, B, C, and D.

Basis: When an EIS is prepared, NEPA requires the NRC to "disclose the significant health, socioeconomic and cumulative consequences of the environmental impact of a proposed action." *Baltimore Gas and Electric Co. v. Natural Resources Defense Council*, 462 U.S. 87, 106-7 (1983), *citing* Council on Environmental Quality

("CEQ:) regulations at 40 C.F.R. §§ 1508.7 and 1508.8. The CEQ defines cumulative impacts as:

> the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

In considering the significance of the environmental impacts of operating fuel pools C and D, the NRC is required by law to evaluate the cumulative impacts of pools C and D in conjunction with the impacts of the current operation, including the environmental risks of operating pools A and B. The risks of high density spent fuel storage purportedly are addressed in the 1979 GEIS for spent fuel storage and handling, which claims that spent fuel pool storage has very low environmental impacts. New information, which has been developed in the time period since publication of the GEIS, shows that the GEIS constitutes an inadequate basis for drawing any conclusions about the environmental impacts of operating fuel pools A and B. *See* Contention EC-1, Section F, which is adopted and incorporated herein by reference. In fact, this new information demonstrates that there is a significant risk that a degraded-core reactor accident will lead to a spent fuel pool accident. The risks of such an accident for pools A and B are comparable to the risks of such an accident for pools C and D.

The NRC Staff should be required to consider the cumulative impacts of adding pools C and D to the operation of pools A and B. The analysis should consider the environmental risks of operating all four spent fuel pools, in light of new information which shows that the risk of a spent fuel pool accident is significant.

As stated in Contention EC-1, the significance of the increment of accident risk at Harris that would arise from operating pools C and D can be determined solely from the proposed configuration and mode of operation of pools C and D and the relationship of pools C and D to the Harris reactor. However, a more complete understanding of the cumulative accident risk associated with fuel storage at Harris would flow from an integrated risk evaluation that considered pools A, B, C and D. Such an integrated evaluation should show how the pool loading pattern, over all four fuel pools, would influence accident risk.[11] This evaluation should also address the potential for an accident at one pool to influence the development of an accident at another pool.

Contention EC-3: Scope of EIS Should Include Brunswick and Robinson Storage

The EIS for the proposed license amendment should include within its scope the storage of spent fuel from the Brunswick and Robinson nuclear power plants.

Basis: As recognized in *Vermont Yankee Nuclear Power Corporation* (Vermont Yankee Nuclear Power Station), LBP-88-19, 28 NRC 145 (1988), there is no independent utility to the racking of a spent fuel pool: the only reason for the application is to permit the expansion of spent fuel storage at the plant. Here, the purpose of the proposed

11 For a given set of accident-initiating events, the fuel loading pattern would influence both the conditional probability and the consequence of a pool accident. The "conditional probability" of an accident is defined above in footnote 8 to Contention EC-1.

expansion is not only to store spent fuel generated by Harris, but also to accommodate fuel from Brunswick and Robinson.

Indeed, CP&L has a global plan for storage of spent fuel from its three North Carolina reactors. A dry storage facility with a capacity of 56 fuel assemblies is in operation at the Robinson plant. CP&L has also pursued the option of dry storage at Brunswick. In 1989, CP&L applied for an ISFSI license for Brunswick. License Application Under 10 C.F.R. Part 72. A review of the correspondence indexed by the NRC Public Document Room does not show that this application was ever withdrawn; and therefore it appears that the application is still pending. The Department of Energy's Energy Information Administration also reports that "The ISFSI at the Brunswick plant will be used only as a backup if shipping of spent nuclear fuel to the Harris plant is prohibited."[12] Thus, the dry cask storage option exists and has been partially developed, and therefore represents a viable alternative to high-density storage in pools C and D that should be considered.

The large quantity of fuel that CP&L seeks to ship from Robinson and Brunswick to the Harris plant could not be stored at Harris *but for* the issuance of the proposed license amendment. This license amendment focuses on only one storage methodology, ignoring other alternatives that are safer and also cost-effective. The NRC Staff should be required to thoroughly examine the alternative of dry storage in an EIS.

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12 EIA Report, SR/CNEAF/96-01, "Spent Nuclear Fuel Discharges from U.S. Reactors, 1994" at 46-47 (February 1996). A copy of the relevant pages is attached as Exhibit 5.

Contention EC-4: Discretionary EIS Warranted

Even if the Licensing Board determines that an EIS is not required under NEPA and 10 C.F.R. § 51.20(a), the Board should nevertheless require an EIS as an exercise of its discretion, as permitted by 10 C.F.R. §§ 51.20(b)(14) and 51.22(b).

Basis: NRC regulations in 10 C.F.R. §§ 51.20(b)(14) and 51.22(b) provide for the preparation of an EIS where, upon its own initiative or request from any party, the Commission finds that "special circumstances" exist. Special circumstances "include the circumstances where the proposed action involves unresolved conflicts concerning alternative uses of available resources within the meaning of section 102(2)(E) of NEPA."

Orange County submits that this case presents such "special circumstances," generally arising from the fact that the proposed expansion of spent fuel pool storage capacity at the Harris plant is part of a larger plan by CP&L for the management of spent fuel generated by three different reactors: Harris, Robinson, and Brunswick. Even if the Licensing Board finds that no EIS is required here, the NRC should nevertheless prepare an EIS in its discretion, in order to evaluate unresolved conflicts concerning the use of available resources for management of spent fuel from CP&L's three reactors.

As recognized in *Vermont Yankee Nuclear Power Corporation* (Vermont Yankee Nuclear Power Station), LBP-88-19, 28 NRC 145 (1988), there is no independent utility to the racking of a spent fuel pool: the only reason for the application is to permit the expansion of spent fuel storage at the plant. Here, the purpose of the proposed expansion is not only to store spent fuel generated by Harris, but also to accommodate fuel from Brunswick and Robinson. The record shows no evaluation by the NRC of the need for

additional storage capacity at any of the three plants, or whether CP&L's proposal constitutes the wisest use of available resources to meet the need. As discussed above in Contention EC-3, it is clear that there is space at the Brunswick plant for dry storage, and that CP&L contemplates dry cask storage there if its proposal for wet storage at Harris fails. Therefore, it is a viable alternative to high-density pool storage at Harris that should be fully considered.

If the proposed license amendment is approved, Shearon Harris will become the largest spent fuel storage facility east of the Mississippi River. As discussed above in Contention EC-1, the inventory of cesium-137 in the Harris spent fuel pools will be greatly increased, thus greatly increasing the consequences of reasonably foreseeable severe accidents. The decisions of whether to use wet or dry storage at Harris, and whether to ship fuel or leave it onsite at Brunswick and Robinson, should not be based on whether shipments to Harris are prohibited, but on which storage alternative is most cost-beneficial, taking into account both environmental and economic considerations. Orange County submits dry storage is a far wiser use of resources from an environmental viewpoint, because it does not entail the risks of a loss of water from the spent fuel pools. Moreover, CP&L's proposal to consolidate spent fuel from Harris, Brunswick, and Robinson into high-density racked pools at one site significantly increases the risk posed by wet storage.

Orange County strongly disputes CP&L's choices regarding the allocation of resources for continued spent fuel storage for its three North Carolina reactors. In light of this conflict regarding the use of available resources, Orange County requests the

preparation of an EIS for storage of spent fuel from the Harris, Brunswick, and Robinson nuclear plants.

Another compelling reason to prepare an EIS for CP&L's spent fuel management proposal is to address the apparent conflict between the CP&L proposal and NRC's Waste Confidence decision. NRC regulations at 10 C.F.R. § 51.23 encode the Commission's "Waste Confidence" determination that, *inter alia*,:

> There is reasonable assurance that at last one mined geologic repository will be available within the first quarter of the twenty-first century, and sufficient repository capacity will be available within 30 years beyond the licensed life for operation of any reactor to dispose of the commercial high-level waste and spent fuel originating in such reactor and generated up to that time.

In contradiction of this finding, the CP&L license amendment application gives, as the rationale for the requested spent fuel pool storage capacity expansion, the fact that "DOE spent fuel storage facilities are not available *and are not expected to be available for the foreseeable future.*" License Application, Enclosure 1 at 1 (emphasis added). Having made a determination that a repository will be available during the next quarter-century, the NRC should evaluate the apparent conflict with CP&L's determination that the resource will be *unavailable.* It should be noted in this regard that the Commission has been quite strict in forbidding state and local governments and intervenor groups from challenging its determination that a repository will be available in the next quarter century. *See, e.g., Private Fuel Storage, L.L.C.* , *supra,* LBP-98-7, 47 NRC at 241; *Vermont Yankee*, *supra*, LBP-87-17, 25 NRC at 853-54. The Commission must be equally strict in enforcing this decision against licensees. The Commission should not leave unexamined a licensee decision to make major changes to its spent fuel storage

program, where that decision is based on a lack of confidence in the Waste Confidence rulemaking.

III. SATISFACTION OF LATE-FILING STANDARDS

As discussed below, Orange County satisfies the standard for late-filed contentions, which is set forth in 10 C.F.R. § 2.714(a)(1).

Good Cause: Orange County has good cause for filing its environmental contentions at the present time. The County originally filed a set of environmental contentions along with its technical contentions, on April 5, 1999. At that time, the Staff had not prepared any environmental studies, or even discussed whether it would do so. At the prehearing conference in May of 1999, the Staff announced that it would prepare an EA. Orange County, CP&L, and the NRC Staff agreed that the Staff's decision to prepare an EA superseded Orange County's environmental contentions. *See* LBP-99-25, Memorandum and Order (Ruling on Standing and Contentions), 50 NRC 25, 39 (1999). The Board agreed the parties' determination, and dismissed the contentions without prejudice to their being raised "at some later juncture, as appropriate." *Id.*

The Staff issued an EA for the proposed license amendment on December 15, 1999. The EA was faxed to counsel for Orange County on December 16, 1999.

Orange County submits that the issuance of the EA establishes the appropriate juncture for filing the County's environmental contentions. The EA contains the Staff's "Finding of No Significant Impact," which determines that no EIS is warranted. Because the County seeks the preparation of a complete EIS for the Harris license amendment, this constitutes the appropriate time to file environmental contentions.

Orange County is filing these contentions within approximately 45 days after receiving the EA. [13] This is a reasonable period of time, especially given the unusual circumstances of this case.[14] This case is being conducted under "Subpart K" of the Commission's rules of practice, which establish special procedures for expedited consideration of spent fuel pool expansion cases. As permitted by the regulations, CP&L had invoked the procedure for oral argument, which involves a three-month discovery period, followed by a relatively short time frame for preparing written summaries of "*all* the facts, data, and arguments which are known to the party at such time and on which the party proposes to rely at the oral argument." 10 C.F.R. § 2.1113(a) (emphasis added). At the time of receiving the EA, Orange County's counsel was engaged more than full-time in preparing a written summaries of evidence and legal arguments regarding the two previously admitted technical contentions, TC-2 (Inadequate Criticality Prevention) and TC-3 (Inadequate Quality Assurance). In accordance with the Licensing Board's schedule, counsel for Orange County filed these written summaries on January 4, 2000. These pleadings amounted to almost 100 pages of detailed factual and legal arguments. In addition, counsel for Orange County submitted numerous exhibits in support of its arguments.

Following submission of the legal summaries, counsel's available time was almost completely taken up with the demands of preparing for the oral argument that was

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13 The 45th day was January 30, a Sunday. This pleading is being filed on the first business day that follows.

14 Orange County notes that in *Private Fuel Storage, L.L.C.* (Private Fuels Storage Facility), LBP-99-3, 49 NRC 40 (1999), *aff'ed on other grounds*, CLI-99-10, 49 NRC 318 (1999), the Licensing Board ruled that under the circumstances of a licensing proceeding for a dry cask storage facility, 45 days was a reasonable time for filing a late

scheduled for January 21, 2000. This effort included responding to evidentiary and legal summaries filed by CP&L and the NRC Staff, as well as voluminous evidentiary exhibits. From January 8 through 17, Orange County's counsel also traveled out of the country for ten days, on a non-vacation trip that had been scheduled far in advance.

The oral argument was held on January 21, 2000, and took an entire day. It was not until the following week that counsel had more than a very brief opportunity to work on the environmental contentions. During that week, counsel missed one day of work because of severe weather conditions that also closed the government for two days. In addition, counsel was unable to communicate with her clients in North Carolina for two days, because the Orange County offices were also closed due to the inclement weather. Counsel also had two other cases that demanded her attention during that week.

Thus, given the demands of presenting written and oral testimony and arguments regarding the County's technical contentions under an expedited schedule, given the fact that Orange County's counsel had to be out of the country for ten days in January, and given the delay caused by inclement weather conditions in January, the County has good cause to file its environmental contentions within approximately 45 days of receiving the EA.

Availability of Other Means to Protect County's Interest: There are no other means for the County to protect its interest in seeking the preparation of an EIS by the NRC. This hearing is the only forum in which the County can seek an EIS and have any recourse to the Commission or the Courts if its request is denied.

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intervention petition .

Extent to Which Orange County's Participation May Reasonably Be Expected to Assist in the Development of a Sound Record: The County's participation in this proceeding may be expected to fully assist in the development of a sound record in this case. The County's contentions are supported by the expert opinion of Dr. Gordon Thompson, an expert in nuclear facility safety and severe accident analysis. His Declaration and CV, which describe his experience in detail, are attached as Exhibit 1.

In support of the contentions, Dr. Thompson has prepared a report which evaluates in detail the severe accident risks posed by expansion of spent fuel storage capacity at Harris, and also examines the inadequacy of current NRC studies to address the issue. If a hearing is granted, Dr. Thompson will provide testimony consistent with the contentions and his report. The County expects that his testimony will have more detail with respect to the specifics of the Harris design, after the County has had an opportunity for discovery.

Extent to Which Orange County's Interests Will be Represented By Another Party: There are no other intervenors in this case, and therefore there are no other parties who can or will represent the County's interests if its contentions are not admitted.

Extent to Which the County's Participation Will Broaden the Issues or Delay the Proceeding: It can be expected that the litigation of environmental contentions will broaden and delay this proceeding significantly beyond the current time-table. This is not the fault of the County, however. CP&L filed its license amendment application on December 23, 1998. The NRC Staff chose to wait almost an entire year before issuing the EA. Had the NRC complied with NEPA in the first place and issued an EA in the

spring of 1999, the County's NEPA compliance issues could have been addressed in the County's original set of contentions. The County has a right to make a timely challenge to the Staff's compliance with NEPA. This right may not be abridged on grounds of broadening or delaying the proceeding.

IV. CONCLUSION

For the foregoing reasons, the County's environmental contentions should be admitted.

Respectfully submitted,

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RISKS AND ALTERNATIVE OPTIONS ASSOCIATED WITH SPENT FUEL STORAGE AT THE SHEARON HARRIS NUCLEAR POWER PLANT

A report

prepared for

Orange County
North Carolina

by

Gordon Thompson

February 1999

001708

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About the author

Gordon Thompson is the executive director of IRSS. He received an undergraduate education in science and mechanical engineering, in Australia. Subsequently, he studied at Oxford University and received from that institution a doctorate of philosophy in mathematics in 1973.

During his professional career, Dr Thompson has performed technical and policy analyses on a range of issues related to international security, energy supply, environmental protection, and the sustainable use of natural resources. Since 1977, a significant part of his 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. Dr Thompson has provided expert testimony in legal and regulatory proceedings, and has served on committees advising US government agencies.

About IRSS

The Institute for Resource and Security Studies is an independent, non-profit corporation. It was founded in 1984 to conduct technical and policy analysis and public education, with the objective of promoting international security and sustainable use of natural resources. IRSS projects always reflect a concern for practical solutions to resource, environment and security problems, and can range from detailed technical studies to preparing educational materials accessible to the public. IRSS actively seeks collaborative relationships with other organizations as it pursues its goals.

Abstract

Orange County, North Carolina, commissioned this report because the licensee of the Shearon Harris nuclear plant has requested an amendment of its operating license. The amendment would permit the activation of two currently unused spent fuel pools at Harris.

This report examines the risks and alternative options associated with spent fuel storage at Harris. The report identifies a potential for severe accidents at the Harris pools. Such accidents could release to the atmosphere an amount of cesium-137 an order of magnitude larger than the release from the 1986 Chernobyl accident. A severe accident at the Harris PWR, with containment failure or bypass, can be expected to initiate a large release from the fuel pools.

Alternative, safer options for spent fuel management are available. These options include dry storage of spent fuel, which is a well-established practice.

Table of contents

1. Introduction

2. Present status of the Harris nuclear plant

3. Proposed activation of fuel pools C and D

4. Types of potential accident at the Harris plant

5. Design-basis pool accidents

6. Severe pool accidents

7. Consequences of potential pool and reactor accidents

8. Alternative options for spent fuel management

9. Addressing risks and alternatives in the regulatory arena

10. Conclusions

Appendix A Spent fuel management at the Harris plant

Appendix B Potential for severe accidents at the Harris reactor

Appendix C Potential for loss of water from the Harris pools

Appendix D Potential for exothermic reactions in the Harris pools

Appendix E Consequences of a large release of cesium-137 from Harris

1. Introduction

Carolina Power & Light Company (CP&L) requested, in December 1998, an amendment of its operating license for the Shearon Harris nuclear plant. The amendment, if granted by the Nuclear Regulatory Commission (NRC), would permit the activation of two currently unused spent fuel pools at Harris. In January 1999, Orange County commissioned this report, which examines the risks and alternative options associated with spent fuel storage at Harris.

Structure of this report

This report has two major components. One component is a main report which is comparatively brief and is intended for a non-specialist audience. The second component is a set of five appendices. These appendices contain detailed, technical material and citations to technical literature. Unless otherwise indicated, discussion in the main report rests upon the more detailed discussion in the appendices.

What is spent fuel?

Figure 1 shows a fuel assembly of the type that is used in the Harris reactor.[1] The fuel rods are 12 feet long, and the assembly is 8.4 inches square. After a fuel assembly is discharged from a reactor, it is "spent" in the sense that it can no longer be used to generate power. However, at this point in its life the assembly is much more dangerous than when it entered the reactor. It emits heat and intense radiation, and contains a large inventory of radioactive material.

Remainder of this report

The remainder of this main report begins with descriptions of the Harris plant (Section 2) and CP&L's intentions regarding the fuel pools at Harris (Section 3). Then, categories of potential accident at Harris are identified (Section 4), followed by descriptions of potential design-basis (Section 5) and severe (Section 6) accidents at the Harris pools. The offsite consequences of potential pool and reactor accidents are addressed in Section 7. Alternative options for spent fuel management are presented (Section 8), followed by a discussion of regulatory processes (Section 9). Conclusions are presented in Section 10.

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[1] Figure 1 is adapted from: A V Nero, A Guidebook to Nuclear Reactors, University of California Press, 1979, page 79.

2. Present status of the Harris nuclear plant

The Harris plant features one pressurized-water reactor (PWR). The core of this reactor contains 157 fuel assemblies, with a center-center distance of about 8.5 inches. The Harris plant was to have four units but only the first unit was built. (A unit consists of a reactor, a turbine-generator and associated equipment.) A fuel handling building was built to serve all four units. This building contains four fuel pools (A, B, C, D), a cask loading pool and three fuel transfer canals, all interconnected but separable by gates.

These pools and transfer canals allow spent fuel to be moved around and stored while remaining under water. The water provides cooling and also shields personnel and equipment from the radiation emitted by the fuel. Shipping casks can carry spent fuel to or from Harris. Casks are loaded and unloaded while submerged in the cask loading pool.

Pools A and B

Pools A and B contain fuel racks, and are in regular use. CP&L says that fresh fuel, and spent fuel recently discharged from the Harris reactor, is stored in pool A. Fuel examination and repair are performed in an open space in pool B. At present, pools C and D are flooded but do not contain racks. The cooling and water cleanup systems for pools C and D were never completed.

Currently, pools A and B store spent fuel from the Harris reactor and from CP&L's Brunswick plant and Robinson plant. The Brunswick plant has two boiling-water reactors (BWRs) while the Robinson plant has one PWR. Shipment of spent fuel from Brunswick and Robinson to Harris is said by CP&L to be necessary to allow sufficient capacity in the pools at Brunswick and Robinson so that the entire core can be removed from the reactor.

Pools A and B now have a combined, potential capacity of 3,669 fuel assemblies. The center-center distance in the racks in pools A and B is 10.5 inches for PWR fuel and 6.25 inches for BWR fuel. This is a much more compact pool storage configuration than was used when nuclear plants first entered service. The United States has no national storage site or repository for spent fuel, so CP&L is currently obliged to store fuel at its plant sites. Compact storage in the existing pools is a comparatively cheap option for on-site storage.

3. Proposed activation of fuel pools C and D

CP&L seeks an amendment to its operating license so that it can activate pools C and D at Harris. By activating these pools, CP&L expects to have sufficient storage capacity at its three nuclear plants to accommodate all the spent fuel discharged by the four CP&L reactors (the Harris and Robinson PWRs and the two Brunswick BWRs) through the ends of their current operating licenses.

Capacity and configuration of pools C and D

CP&L plans to install racks in pool C in three campaigns (approximately in 2000, 2005 and 2014), to create a total capacity in this pool of 3,690 fuel assemblies. Thereafter, CP&L plans to install racks in pool D in two campaigns (approximately in 2016 and at a date to be determined), to create 1,025 spaces. Thus, the ultimate capacity of pools C and D will be 4,715 fuel assemblies. The center-center distance in the racks used in these pools will be 9.0 inches for PWR fuel and 6.25 inches for BWR fuel. In pool C, the space between the outermost racks and the pool wall will be 1-2 inches.

The PWR racks in pools C and D will have a smaller center-center distance than the racks in pools A and B (9.0 inches instead of 10.5 inches). This highly compact arrangement allows more PWR fuel to be placed in a given pool area but also has adverse implications for safety.

Cooling and electrical supply for pools C and D

The water in a spent fuel pool must be cooled and cleaned. Cooling is performed by circulating pool water through heat exchangers, where its heat is transferred to a secondary cooling system. At Harris, the secondary cooling system is the component cooling water (CCW) system. When the Harris plant was designed, the intention was that pools C and D would be cooled by the CCW system for Unit 2. Also, electricity would have been supplied to the circulating pumps at pools C and D from the electrical systems of Unit 2. However, Unit 2 was never built and its CCW and electrical systems do not exist.

CP&L's current plan is to cool pools C and D by completing their partially built cooling systems and connecting those systems to the Unit 1 CCW system. Electricity will be supplied to pools C and D from the electrical systems of Unit 1. The Unit 1 CCW system already provides cooling to pools A and B and serves other, important safety functions. For example, the Unit 1 CCW system provides cooling for the residual heat removal (RHR) system and reactor coolant pumps of the Unit 1 reactor.

Independent support systems for pools C and D

During CP&L's planning for the activation of pools C and D, the company considered the construction of an independent system to cool these pools. Within that option, CP&L considered the further possibility of providing dedicated emergency diesel generators to meet the electrical needs of pools C and D if normal electricity supply were unavailable. Construction of an independent cooling system for pools C and D, supported by dedicated emergency diesel generators, could provide the level of safety that was associated with the original design concept for Harris. However, CP&L has not proceeded with this option.

Capacity of the Unit 1 CCW system

In its present form, the Unit 1 CCW system cannot absorb the additional heat load that will ultimately arise from activation of pools C and D. Over the first few years of pool use, while the heat load is comparatively small, CP&L proposes to exploit the margin in the Unit 1 CCW system. Subsequently, CP&L intends to upgrade the Unit 1 CCW system so that it can accommodate the full heat load from pools C and D, and can also accommodate an anticipated power uprate for the Unit 1 reactor.

Safety implications

In order to exploit the margin in the existing CCW system so as to cool pools C and D, CP&L may be obliged to require its operators to divert some CCW flow from the RHR heat exchangers during the recirculation phase of a design-basis loss-of-coolant accident (LOCA) event at the Harris reactor. This is a safety issue because, during the recirculation phase of a LOCA, operation of the RHR system is essential to keeping the reactor core and containment in a safe condition. CP&L's exploitation of the margin in the existing CCW system is deemed by CP&L and NRC to constitute an "unreviewed safety question".

Lack of QA documentation

Activation of pools C and D will require the completion of their cooling and water cleanup systems, and the connection of their cooling systems to the Unit 1 CCW system. CP&L states that approximately 80 percent of the necessary piping was completed before the second Harris reactor was cancelled. However, some of the quality assurance (QA) documentation for the completed piping is no longer available. Much of the completed piping is embedded in concrete and is therefore difficult or impossible to inspect. To

address this situation, CP&L proposes an "alternative plan" to demonstrate that the previously completed piping and other equipment is adequate for its purpose. Nevertheless, the cooling systems for pools C and D will not satisfy prevailing code requirements.

4. Types of potential accident at the Harris plant

Most of the radioactive material at the Harris plant is either in the reactor or in the spent fuel pools. Thus, these locations are of primary concern when one considers the potential for accidents. This report focusses on the potential for accidents in the reactor or the pools. At present, pools C and D at Harris pose no accident potential, because they are unused.

Some potential accidents could cause injury to plant personnel, without causing any offsite effects. Other potential accidents could release radioactive material beyond the plant boundary, causing offsite effects. The radioactive material could be released as an atmospheric plume, or into ground or surface waters. This report focusses on accidents that release an atmospheric plume which travels beyond the plant boundary. Such a plume will contain radioactive material in the form of gases and small particles. As the plume travels downwind, the small particles will be deposited onto land, bodies of water, structures and vegetation.

Design-basis and severe accidents

A nuclear plant is designed to accommodate the effects of a specified set of accidents, known as "design-basis" accidents. If the plant is properly designed and constructed, if its equipment and operators function in the required manner, and if external influences (e.g., earthquakes) do not exceed specified levels, then the offsite effects of a design-basis accident will be small. Design-basis accidents and their anticipated effects are described in a Final Safety Analysis Report (FSAR) prepared and regularly updated by the licensee.

In the early years of the nuclear industry, some people equated design-basis accidents with "credible" accidents. However, research and operating experience soon revealed that accidents more severe than the design basis are credible. The first systematic study of the potential for severe accidents was the Reactor Safety Study, completed and published by the NRC in 1975. "Severe" accidents are conventionally defined as accidents involving substantial damage to fuel, with or without a substantial release of radioactivity to the environment.

The Three Mile Island (TMI) reactor accident of 1979 was a demonstration of the potential for severe accidents. Soon thereafter, the NRC promulgated

regulations which require an emergency response plan for each nuclear plant. These plans allow for large releases of radioactive material, of the kind that were identified in the Reactor Safety Study. The Chernobyl reactor accident of 1986 further demonstrated the potential for severe accidents. While the TMI accident released a small fraction of the reactor core's inventory of radioactivity, the release fraction during the Chernobyl accident was large.

Since the TMI accident, the NRC's safety regulation of nuclear plants has been guided by a hybrid set of assumptions. Many areas of safety regulation rely upon the assumption that accidents will remain within the design basis. Other areas, such as emergency response planning, assume that severe accidents can occur.

Pool-reactor interactions

At the Harris plant, the reactor and the fuel pools are adjacent, and they share support systems such as the Unit 1 CCW system and the emergency diesel generators. Thus, it is important to understand if an accident at the Harris reactor could accompany, initiate or exacerbate an accident at the Harris pools, or vice versa. The NRC has been slow to examine the potential for safety interactions between reactors and fuel pools. Neither CP&L nor the NRC has assessed the potential for these interactions at Harris.

PRAs and IPEs

A discipline known as probabilistic risk assessment (PRA) has been developed to examine the probabilities and consequences of potential accidents at nuclear facilities. PRA techniques are most highly developed in their application to reactor accidents, but can be applied to fuel pool accidents. Appendix B describes the characteristics, strengths and limitations of PRA.

CP&L has prepared a Level 2, internal-events PRA for the Harris reactor, in the form of an Individual Plant Examination (IPE). Also, CP&L has performed a limited assessment of the vulnerability of the Harris reactor to earthquakes and in-plant fires, in the form of an Individual Plant Examination for External Events (IPEEE).

The Harris IPE and IPEEE could be extended to encompass fuel pool accidents as well as reactor accidents. Such an extension would be logical, because there are various ways in which a severe accident or a design-basis accident at the Harris reactor might accompany, initiate or exacerbate an accident at the Harris fuel pools, or vice versa. However, there is no current indication that CP&L will extend the IPE or IPEEE, or will otherwise apply PRA techniques to potential accidents at the Harris fuel pools.

5. Design-basis pool accidents

The Harris FSAR considers two types of design-basis accident in the Harris fuel pools. One type of accident involves the dropping of a fuel assembly, while the other type involves the dropping of a shipping cask (but not into a fuel pool). In both cases, the FSAR estimates that the release of radioactivity would be relatively small. This report does not review the FSAR analysis.

In its license amendment application, CP&L has considered some other potential accidents, including the dropping of a rack or a fuel pool gate.[2] CP&L's analysis of these accident scenarios is limited in scope. Accidents of this type may be in an intermediate class of severity, and that potential class deserves further analysis.[3] This report focusses on the potential for severe accidents.

It should be noted that the use of pools C and D at Harris will involve many additional cask, fuel and rack movements. These additional movements will increase the cumulative probability of accidents associated with such movements.

6. Severe pool accidents

Spent fuel is stored in a compact, high-density configuration in pools A and B at Harris. CP&L's proposed activation of pools C and D will involve an even higher density of storage. Such high-density configurations inhibit heat loss from the fuel if water is partially or totally lost from a pool. As a result, partial or total loss of water can lead to an exothermic (heat-producing) reaction of the fuel cladding with air or steam. Such a reaction could liberate a large amount of radioactive material from the fuel.

Thus, two questions become important. First, what circumstances could cause a partial or total loss of water? This question is addressed in Appendix C. Second, will an exothermic reaction be initiated if water is lost? That question is addressed in Appendix D.

Potential for loss of water

A variety of events could cause partial or total loss of water from the Harris pools. These events deserve the level of analysis that would be provided by a thorough PRA. Performing a pool accident PRA is beyond the scope of our

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[2] License amendment application, Enclosure 7.

[3] A potential accident in this class, which deserves analysis, would involve the placement of a low-burnup or high-enrichment PWR assembly in the racks in pools C or D.

present work for Orange County. Here, the focus is on two types of event – a reactor accident, and a sabotage/terrorism event. Consideration of these events demonstrates clearly that loss of water from the Harris pools is a credible accident.

The Harris IPE – prepared by CP&L – examines the potential for severe accidents at the Harris reactor. It identifies a category of severe accidents that would involve failure or bypass of the reactor containment. The IPE estimates the collective probability of accidents in this category to be 1 per 100,000 reactor-years.[4] Occurrence of accidents in this category would contaminate the plant with radioactivity, to the point where personnel access would almost certainly be precluded. Water would then be evaporated from the fuel pools, and fuel would be uncovered after a delay of perhaps 10 days.

A credible sabotage/terrorism event at Harris would involve a group taking control of the fuel handling building, shutting down the pool cooling systems, and siphoning water from the pools. The group would require military skills and equipment to take control of the fuel handling building. Siphoning water from the pools would be a comparatively easy task. Escape by the group would be difficult but not impossible. The probability of this event cannot be predicted by PRA techniques.

Initiation of exothermic reactions, given water loss

Since the late 1970s, the NRC has sponsored and performed a variety of studies that have examined the outcomes of a loss of water from a fuel pool. These studies have focussed almost entirely on the instantaneous, total loss of water from a pool. Computer models have been developed to investigate this situation. For a high-density pool configuration, current models suggest that an exothermic reaction will be initiated in fuel aged up to 1-2 years after discharge from a reactor. These models have not been applied to the specific configuration of the Harris pools.

Partial loss of water can be expected in many scenarios, rather than instantaneous, total loss of water. Partial loss of water can be a more severe situation, because convective heat transfer from fuel assemblies is inhibited. The NRC has neglected this issue. Preliminary analysis suggests that partial water loss could initiate an exothermic reaction in fuel aged 10 years after discharge.

[4] This probability estimate should be accompanied by a range of uncertainty. Even with the inclusion of uncertainties, PRA-derived estimates represent lower bounds to actual accident probabilities.

An exothermic reaction could propagate from one set of fuel assemblies to an adjacent set of assemblies that might not otherwise suffer such a reaction. The NRC's studies of propagation are incomplete, but they acknowledge the potential for propagation.

Exothermic reactions in the Harris pools

CP&L representatives have stated that spent fuel assemblies will not be placed in pools C and D at Harris until the assemblies have aged for 5 years after discharge. However, there is nothing in CP&L's license amendment application that prohibits the placement of more recently-discharged fuel in pools C and D. In any case, preliminary analysis suggests that partial water loss could initiate an exothermic reaction in fuel aged 10 years after discharge. Thus, exothermic reactions could occur in pools C and D.

For the purpose of estimating the potential consequences of a pool accident at Harris, this report considers two scenarios for exothermic reactions. One scenario involves fuel aged up to 3 years after discharge from a reactor, while the second scenario involves fuel aged up to 9 years after discharge from a reactor. In both cases, it is assumed that the entire inventory of cesium in the affected fuel assemblies would be released to the atmosphere. This assumption is consistent with NRC studies.

7. Consequences of potential pool and reactor accidents

This report focusses on accidents that release an atmospheric plume which travels beyond the plant boundary. The consequences of such a release can be estimated by site-specific computer models. Here, a simpler approach is used, but this approach is adequate to show the nature and scale of expected consequences. The approach is described in Appendix E.

The role of cesium-137

The consequences of a pool accident can be adequately illustrated by examining a release of only one radioisotope – cesium-137. This isotope has a half-life of 30 years and is liberally released from damaged fuel. It dominates the offsite radiation exposure from the 1986 Chernobyl accident, and is a major contributor to radiation exposure attributable to fallout from the atmospheric testing of nuclear weapons in the 1950s and 1960s.

Three atmospheric releases of cesium-137 are postulated here for the purpose of examining consequences. First, a release of about 2 million Curies (2 MCi) corresponds to the most severe reactor accident identified in the Harris IPE. Second, a release of about 20 million Curies (20 MCi) corresponds to a pool

accident affecting fuel aged up to 3 years after discharge from a reactor. Third, a release of about 70 million Curies (70 MCi) corresponds to a pool accident affecting fuel aged up to 9 years after discharge from a reactor.

Land contamination by cesium-137

Accident consequences are illustrated here by estimating the area of land that would be contaminated by cesium-137 to a level such that inhabitants would suffer an external radiation dose in excess of 10 rem over 30 years.[5] An exposure of 10 rem over 30 years would represent about a three-fold increase above the typical level of background radiation (which is about 0.1 rem/year). In its Reactor Safety Study, the NRC used a threshold of 10 rem over 30 years as an exposure level above which populations were assumed to be relocated from rural areas. The same study used a threshold of 25 rem over 30 years as a criterion for relocating people from urban areas, to reflect the assumed greater expense of relocating urban inhabitants.

In an actual case of land contamination in the United States, the steps taken to relocate populations and pursue other countermeasures (decontamination of surfaces, interdiction of food supplies, etc.) would reflect a variety of political, economic, cultural, legal and scientific influences. It is safe to say that few citizens would calmly accept a level of radiation exposure which substantially exceeds background levels.

For typical meteorology, a release of 2 MCi would contaminate 4,000-5,000 square kilometers of land, A release of 20 MCi would contaminate 50,000-60,000 square kilometers. Finally, a release of 70 MCI would contaminate about 150,000 square kilometers of land. Note that the total area of North Carolina is 136,000 square kilometers and the state's land area is 127,000 square kilometers.

Health effects of radiation

There is ongoing debate about the health effects of radiation at comparatively low doses. According to estimates by the National Research Council's BEIR V committee, a continuous exposure throughout life at a rate of 0.1 rem/year (above background) will increase the number of fatal cancers, above the normally expected level, by 2.5 percent for males and 3.4 percent for females, with an average of 16-18 years of life lost per excess death. If the dose-response function were linear, it would follow that continuous, lifetime exposure to 1 rem/year would increase the number of fatal cancers by 25

[5] Without countermeasures such as interdiction of food supplies, the internal dose could be of a similar magnitude to the external dose.

percent for males and 34 percent for females. The shape of the dose-response function is a subject of debate.

8. Alternative options for spent fuel management

The present mode of spent fuel storage in Harris pools A and B poses a major hazard. This hazard will be substantially increased if pools C and D are activated. CP&L has not properly characterized the present and potential hazard, nor has the company provided a systematic assessment of alternative options.

A situation like this calls for a systematic, comprehensive assessment of alternative options and their impacts. A full range of alternatives should be identified, and their impacts and other characteristics should be assessed. Performance of such an analysis is beyond the scope of the author's current work for Orange County. An abbreviated discussion is presented here.

Options not reviewed here

One option would be to cease operation of CP&L's nuclear plants. That option, which could be combined with other options for storage of CP&L's present stock of spent fuel, is not reviewed here. Another set of options would employ high-density pool storage but would introduce technical measures that sought to increase the reliability of the cooling systems for some or all of the Harris pools, or to decrease the potential for safety interactions between the pools and the reactor. Independent support systems for pools C and D, as mentioned in Section 3, would be in this class of options. Such options are not reviewed here.

Options reviewed here

This report focusses on two classes of options for spent fuel storage. One class involves dry storage of spent fuel, using proven technology. The second class, which could complement dry storage, involves low-density storage in pools. A combination of dry storage and low-density pool storage could offer a practical, proven means of dramatically decreasing the hazard posed by high-density pool storage at Harris.

Dry storage

The NRC has approved a variety of designs for the dry storage of spent fuel. These designs are described in Table 1, and their current use by licensees is

described in Table 2.[6] It will be noted from Table 2 that a dry storage installation is licensed at CP&L's Robinson plant. This installation employs eight NUHOMS-7P modules, each of which can hold 7 fuel assemblies. All eight modules are fully loaded.[7]

Dry storage could be implemented at any of CP&L's three plant sites. This report does not recommend any particular design, but notes that the designs vary in their level of safety and other features. For example, some designs are more resistant to sabotage than others.

All of the approved dry storage designs are safe in the event that access to the plant site is precluded by the release of radioactive material during a reactor accident. None of the designs requires active cooling, electricity or operator attention. A sabotage/terrorism event at a dry storage installation could release only a small fraction of the radioactive material that could be released by a sabotage/terrorism event at the Harris pools in their present and proposed configuration. Overall, dry storage poses a much lower level of hazard than high-density pool storage, for the same quantity of fuel.

At present, the NRC licenses dry storage installations for only 20 years. However, the technology is capable of storing fuel for much longer periods. If CP&L employs the dry storage option, they should choose a design that has this capability. This choice, properly documented and supported by ongoing testing, would establish the basis for a license extension in the future.

Low-density pool storage

Spent fuel can be stored in pools in a low-density, open-rack configuration, as was common practice when nuclear plants were first operated. Given a sufficiently low-density configuration, partial or total uncovering of the fuel will not initiate an exothermic reaction in the fuel cladding, even for recently discharged fuel. The fuel would remain vulnerable to consolidation through a cask drop into a pool or a severe earthquake which disrupts the fuel racks. If such consolidation were accompanied by partial or total uncovering, an exothermic reaction could occur in the consolidated region. However, it is unlikely that this reaction would be propagated to other regions of a pool.

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[6] Tables 1 and 2 are adapted from: US Nuclear Regulatory Commission, Information Digest, 1998 Edition, NUREG-1350, Volume 10, November 1998.
[7] M G Raddatz and M D Waters, Information Handbook on Independent Spent Fuel Storage Installations, NUREG-1571, December 1996.

Summary

CP&L could employ a spent fuel storage strategy which combines dry storage with low-density pool storage. Some or all of pools A, B, C and D at Harris would be used in a low-density configuration. If appropriately designed and implemented, this strategy could dramatically reduce the hazard posed by present and proposed fuel storage arrangements at Harris.

9. Addressing risks and alternatives in the regulatory arena

Orange County has requested the NRC to hold a hearing regarding CP&L's license amendment application, and the NRC has established a Licensing Board for this case. These actions have initiated a regulatory process which has been employed many times before. A review of this process is beyond the scope of this report, but some brief observations may be helpful.

The licensing process will typically assume that regulatory decisions taken in the past were correct. Thus, the existing operations at Harris pools A and B might be held to establish a precedent for the proposed operations at pools C and D. However, this report shows that the NRC has not properly analyzed the potential for severe pool accidents at a generic level. This point may or may not influence the NRC's regulatory process, but it deserves continuing emphasis through all available channels.

At Harris, and nationwide, there is a need for a thorough assessment of the hazards associated with high-density pool storage, and of alternative options which could pose a lower hazard. Orange County would provide an important public service if it could persuade the NRC or another body to conduct such an assessment, perhaps in the form of an environmental impact statement. There has been discussion about the US Department of Energy taking title to the nation's spent fuel, while the fuel remains at plant sites. This move could provide an opportunity for a thorough assessment of risks and options, and for the adoption of safer means of fuel storage.

10. Conclusions

C1 Given the present and proposed configuration of spent fuel storage in the Harris pools, partial or total loss of water from the pools could initiate exothermic reactions of fuel cladding, in any or all of pools A, B, C and D.

C2 Partial or total loss of water from the Harris pools could occur through a variety of events including acts of malice, and would be an almost certain outcome of a severe reactor accident at Harris involving containment failure

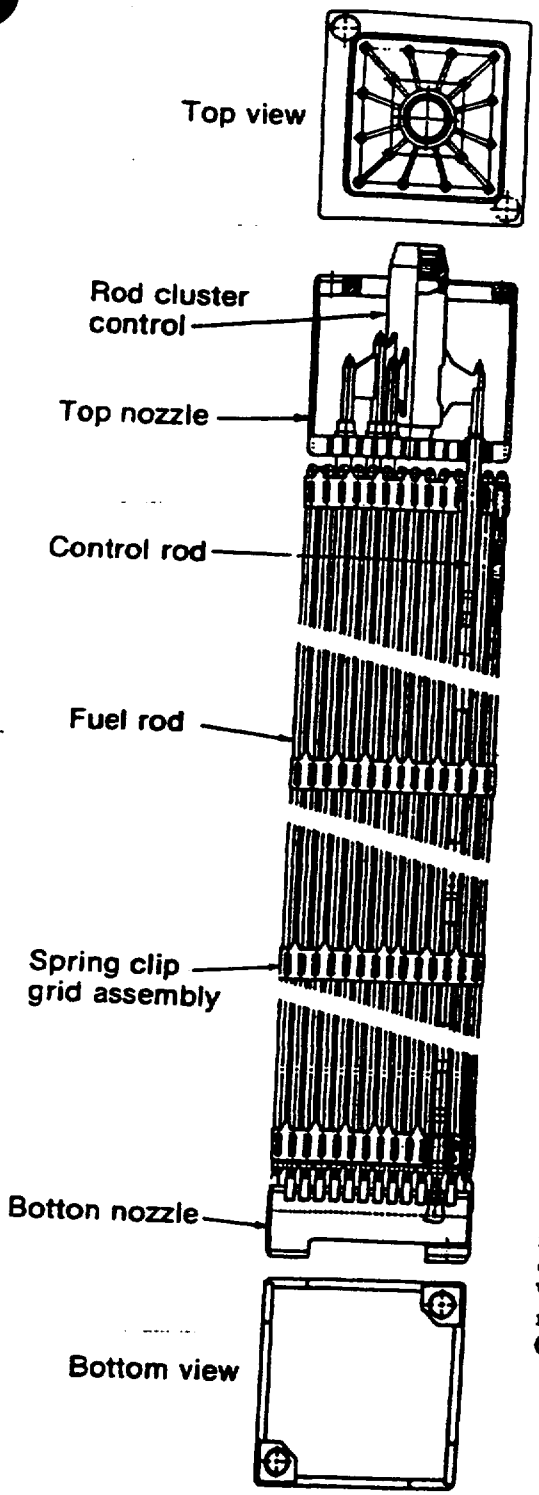
or bypass; CP&L estimates the probability of the latter event as 1 per 100,000 reactor-years.

C3 Exothermic reactions in the Harris pools could release to the environment an amount of cesium-137 at least an order of magnitude larger than the amount released by the most severe potential accident at the Harris reactor.

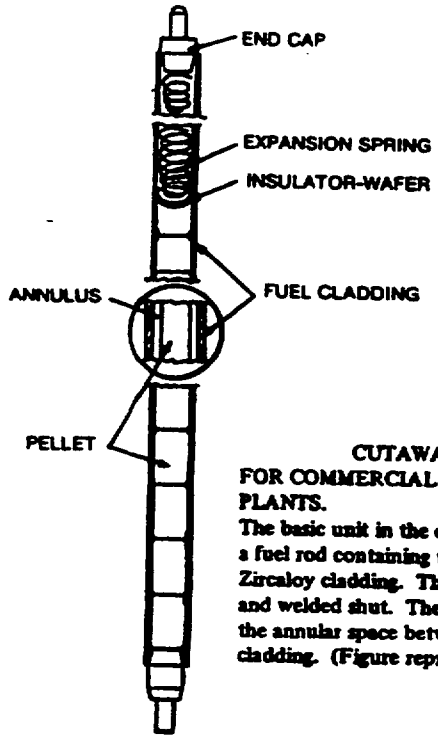
C4 A large release of cesium-137, as could occur from exothermic reactions in the Harris pools, could significantly contaminate an area of land equal to the area of North Carolina.

C5 The probability and magnitude of a potential release from Harris of radioactive material in spent fuel could be dramatically reduced if CP&L adopted a fuel storage strategy which combines dry storage with low-density pool storage; this strategy would employ proven technology.

C6 Activation of pools C and D at Harris could increase the probability and magnitude of design-basis or severe accidents at the Harris fuel pools or reactor.



FUEL ASSEMBLY FOR A PRESSURIZED-WATER REACTOR.
In a pressurized-water reactor, fuel rods are assembled into a square array, held together by spring clip assemblies and by nozzles at the top and bottom. The structure is open, permitting flow of coolant both vertically and horizontally. All the assemblies in the reactor may have the same mechanical design, including provision for passage of a control rod cluster (shown in the figure). Where there is no cluster, these positions may have neutron sources, burnable poison rods, or plugs. (Figure reproduced from WASH-1250.)



CUTAWAY VIEW OF OXIDE FUEL FOR COMMERCIAL LWR POWER PLANTS.
The basic unit in the core of a light-water reactor is a fuel rod containing uranium oxide pellets in a Zircaloy cladding. The rod is filled will helium gas and welded shut. The circled portion exaggerates the annular space between the pellet and the cladding. (Figure reproduced from WASH-1250.)

Figure 1

Fuel for a pressurized-water reactor

Vendor	Storage Design Model	Capacity (Assemblies)	Storage Design Approval Date	Certificate of Compliance Approval Date
General Nuclear Systems, Incorporated	Metal Cask CASTOR V/21 CASTOR X/28 CASTOR X/33	 21 PWR 28 PWR 33 PWR	 09/30/1985 04/22/1994 11/24/1995	08/17/1990
Transnuclear, West Incorporated	Concrete Module NUHOMS-7P	7 PWR	 03/28/1986	
Westinghouse Electric	Metal Cask MC-10	24 PWR	09/30/1987	08/17/1990
FW Energy Applications, Incorporated	Concrete Vault Modular Vault Dry Storage (MVDS)	83 PWR or 150 BWR	03/22/1988	
NAC International, Inc.	Metal Cask NAC S/T	26 PWR	03/29/1988	08/17/1990
NAC International, Inc.	Metal Cask NAC-C28 S/T	28 Canisters (fuel rods from 56 PWR assemblies)	09/29/1988	08/17/1990
Transnuclear, Incorporated	Metal Cask TN-24 TN-32	 24 PWR 32 PWR	 07/05/1989 11/07/1996	11/04/1993
NAC International, Inc.	Metal Cask NAC-128/ST	28 PWR	02/01/1990	
Sierra Nuclear Corporation	Ventilated Cask VSC-24	24 PWR	03/29/1991	05/03/1993
Transnuclear West, Inc.	Concrete Module Standardized NUHOMS-24P NUHOMS-52B	 24 PWR 52 BWR	04/21/1989	01/18/1995
NAC International, Inc.	NAC-STC	26 PWR	07/17/1995	

Note: PWR - Pressurized-Water Reactor; BWR - Boiling-Water Reactor

Table 1

NRC-approved dry spent fuel storage designs

Reactor Name Utility	Date Issued	Vendor	Storage Model
Surry 1, 2 Virginia Electric & Power Company	07/02/1986	Generals Nuclear Systems, Incorporated	Metal Cask CASTOR V/21 TN-32 NAC-128 CASTOR X/33 MC-10
H. B. Robinson 2 Carolina Power & Light Company	08/13/1986	Transnuclear West, Incorporated	Concrete Module NUHOMS-7P
Oconee 1, 2, 3 Duke Energy Company	01/29/1990	Transnuclear West, Incorporated	Concrete Module NUHOMS-24P
Fort St. Vrain* Public Service Company of Colorado	11/04/1991	FW Energy Applications, Incorporated	Modular Vault Dry Store
Calvert Cliffs 1, 2 Baltimore Gas & Electric Company	11/25/1992	Transnuclear West, Incorporated	Concrete Module NUHOMS-24P
Palisades Consumers Energy	Under General License	Pacific Sierra Nuclear Associates	Ventilated Cask VSC-24
Prairie Island 1, 2 Northern States Power Company	10/19/1993	Transnuclear West, Incorporated	Metal Cask TN-40
Point Beach Wisconsin Electric Power Company	Under General License	Sierra Nuclear Corporation	Ventilated Cask VSC-24
Davis-Besse Toledo Edison Company	Under General License	Transnuclear West, Incorporated	Concrete Module NUHOMS-24P
Arkansas Nuclear One Entergy Operations	Under General License	Sierra Nuclear Corporation	Ventilated Cask VSC-24
North Anna Virginia Electric & Power Company	06/30/98	Transnuclear West, Incorporated	Metal Cask TN-32

*Plant undergoing decommissioning

Table 2

NRC dry spent fuel storage licensees