Critique of the Analysis of Safety and Environmental Risks Posed by Spent Fuel Pool Leaks in the NRC's Draft Waste Confidence Generic Environmental Impact Statement

Declaration of David Lochbaum

Under penalty of perjury, I, David Lochbaum, declare as follows:

I. INTRODUCTION

1.1 I am the director of the nuclear safety project for the Union of Concerned Scientists (UCS). The UCS puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future. The UCS has over 93,000 members.

1.2 I have been retained by a group of environmental organizations to assist in the preparation of comments invited by the U.S. Nuclear Regulatory Commission (NRC), on its Draft Generic Environmental Impact Statement on the Waste Confidence Decision (WC DGEIS).

1.3 The purpose of my declaration is to address the adequacy of the discussion of spent fuel pool leak risks in the WC DGEIS to support the NRC's proposed finding in 10 CFR. § 51.23(a)(2) that it is feasible to safely store spent nuclear fuel in spent fuel pools after nuclear power reactors permanently cease operation.

1.4 My declaration is organized as follows:

- Section II (page 3) discusses my professional qualifications.
- Section III (page 5) provides introductory material on spent fuel storage in the United States and treatment of spent fuel pool leaks within the WC DGEIS.
- Section IV (page 10) discusses the NRC's failure to evaluate experience from past spent fuel pool leaks in assessing future spent fuel pool leak risks for the WC DGEIS.
- Section V (page 19) discusses the inadequacy of the WC DGEIS with regard to the difficulties and limitations that are inherent with detecting leaks from spent fuel pools.
- Section VI (page 21) discusses the inadequacy of the WC DGEIS with respect to incorrect and invalid assumptions regarding the coverage, applicability, and associated reliability of inspection and monitoring requirements.
- Section VII (page 31) discusses the inadequacy of the WC DGEIS with respect to its failure to consider the significant reduction in regulatory requirements and oversight that occurs after a reactor ceases operating.
- Section VIII (page 43) discusses the inadequacy of the WC DGEIS with respect to its consideration of a number of impacts, including onsite impacts and socioeconomic impacts.
- Section IX (page 46) provides a conclusion of the arguments made in this declaration.
- Section X (page 48) lists the sources reviewed in preparing this declaration.

- Appendix A summarizes the results from NRC's inspections of voluntary groundwater protection programs implemented at nuclear power plant sites.
- Appendix B lists inspections routinely conducted by the NRC at operating nuclear power plants.
- Appendix C shows results from NRC's inspection efforts at operating nuclear power plants.
- Appendix D provides my curriculum vitae.

1.5 In preparing this declaration, I have reviewed the WC DGEIS, the relevant references listed in the WC DGEIS, and the documents listed in Section X of this declaration.

II. PROFESSIONAL QUALIFICATIONS

2.1 As stated in Section I, I am the director of the nuclear safety project for the UCS. I graduated in June 1979 from The University of Tennessee with a Bachelor of Science degree in nuclear engineering. Appendix D contains my curriculum vitae.

2.2 Except for a one-year gap beginning in March 2009, I have worked for UCS since October 1996. In directing UCS's nuclear safety program, I monitor developments in the nuclear industry, serve as the organization's spokesperson on nuclear safety issues, initiate action to correct safety concerns, author reports and briefs on safety issues, and present findings to the Nuclear Regulatory Commission (NRC), the US Congress, state and local officials, and others. From March 2009 to March 2010, I was a reactor technology instructor for the Nuclear Regulatory Commission where I provided initial qualification and re-qualification training on boiling water reactor technology for NRC employees. My assigned duties included revising chapters of the training manual, conducting classroom and control room simulator training sessions, maintaining the test question database, and administering examinations. From June 1979 through September 1996, I worked in the U.S. commercial nuclear power industry. Most of that period was spent in assignments at nuclear plant sites supporting operating reactors. I began as a junior engineer responsible for the liquid and solid radioactive waste management systems at the Hatch nuclear plant. I subsequently worked as a reactor engineer and Shift Technical Advisor at the Browns Ferry nuclear plant, and as the supervisor of the reactor engineers and Shift Technical Advisors at the Grand Gulf nuclear plant. I had assignments as a consultant in the licensing departments for the Grand Gulf, Brunswick, Salem, Wolf Creek and Connecticut Yankee nuclear plants and the engineering departments at the Perry, FitzPatrick and Susquehanna nuclear plants.

2.3 I am familiar with nuclear plant regulatory requirements, including those applicable to spent fuel pools, and the NRC's inspection regime. For example, I developed a lesson plan on design and licensing bases issues and conducted training on it to managers at the Perry nuclear plant. I developed a topical report on the station blackout licensing bases for the Connecticut Yankee nuclear plant. I participated in a vertical slice assessment of the spent fuel pool cooling system at the Salem Generating Station. I developed the primary containment isolation devices design basis document for the FitzPatrick nuclear plant. I conducted design reviews of balance of plant systems, including the spent fuel pool cooling and cleanup system, to support the power uprate program for the Susquehanna nuclear plant. I co-authored a report submitted to the NRC in November 1992 pursuant to 10 CFR. Part 21 regarding design and licensing bases inadequacies associated with the two spent fuel pools at the Susquehanna nuclear plant. In January 2010, I was certified as a boiling water reactor technology instructor at the NRC's Technical Training Center. In April 1982, I was certified as a Shift Technical Advisor at the Browns Ferry nuclear plant

2.4 I am the author of *Nuclear Waste Disposal Crisis*, a book published in January 1996 by PennWell Books in Tulsa, Oklahoma. Chapter 1 of this book summarized the history of the nuclear power industry in the United States. Chapter 2 described the nuclear fuel cycle. Chapter 3 summarized the different designs used for U.S. nuclear power reactors. Chapter 4 described spent fuel storage at nuclear plants, including spent fuel pools, storage racks, cooling and cleanup systems for the pools, spent fuel pool temperature and water level instrumentation, and fuel handling equipment. Chapter 5 covered the history of reprocessing of spent fuel in the United States. Chapter 6 addressed plans for disposing of spent fuel in geological repositories. Chapter 7 discussed several actual and proposed methods for interim spent fuel storage at nuclear plant sites. Chapter 8 described the risks from onsite spent fuel storage. Chapter 9 covered the concerns Don Prevatte and I raised to the NRC about spent fuel storage at the Susquehanna nuclear plant in Pennsylvania. (Our concerns were both valid and relevant as evidenced by the NRC issuing a warning letter (NRC 1993) to plants owners and technical report (NRC 1997b) on the issues.) Chapter 10 provided recommendations for managing the interim and long-term risks of spent fuel storage and disposal. And Appendix A of the book covered past spent fuel incidents, including ones involving loss of water inventory from spent fuel pools.

III. BACKGROUND ON SPENT FUEL STORAGE AND CONSIDERATION OF SPENT FUEL POOL LEAKS IN THE WC DGEIS

A. History of Onsite Spent Fuel Storage

3.1 The oldest nuclear power reactors currently operating in the United States were licensed by the Atomic Energy Commission (AEC) (NRC's predecessor) in the 1960s (NRC 2013d, Appendix A). At that time, the strategy called for spent fuel to remain onsite for a relatively short time (weeks to months) before being transferred offsite for either reprocessing or disposal. Consequently, the capacity of spent fuel pools was limited to only about one and one-third reactor cores (Kadak 2012, page 25). This design capacity accommodated the fuel from an entire reactor core if it needed to be offloaded to inspect the reactor vessel and/or its internals or other reasons along with one-third of a reactor core discharged during a recent refueling outage but not yet shipped to a repository or reprocessing facility.

3.2 Safety studies performed by applicants for licenses to operate nuclear power plants and reviewed by the NRC (or AEC) before issuing them examined several postulated accidents and transients having the potential to cause damage to the reactor core. For example, the largest diameter pipe connected to the reactor vessel was postulated to rupture and drain cooling water, and the offsite grid supplying electricity to the plant and its equipment was postulated to fail. These studies supported conclusions that plant design features and procedures adequately protected workers and members of the public from these hazards if they were to occur.

3.3 The only scenarios involving spent fuel at the plants involved handling accidents—an irradiated fuel assembly being dropped onto other irradiated fuel assemblies in storage racks within spent fuel pools or an irradiated fuel assembly being damaged by colliding with something during movement. Other scenarios, such as loss of water inventory[1] from spent fuel pools and interruption of cooling of the spent fuel pool water, were not studied. As noted in paragraph 3.2 above, loss of water inventory and interruption of cooling were studied with regard to their potentially damaging irradiated fuel in the reactor cores.

3.4 It is my professional opinion that spent fuel pool scenarios, other than fuel handling events, were not studied primarily due to the original strategy for onsite spent fuel storage described in paragraph 3.1 above. Because spent fuel was presumed to remain onsite for a short time before being shipped offsite, these "temporary" configurations were subjected to less rigorous evaluations.

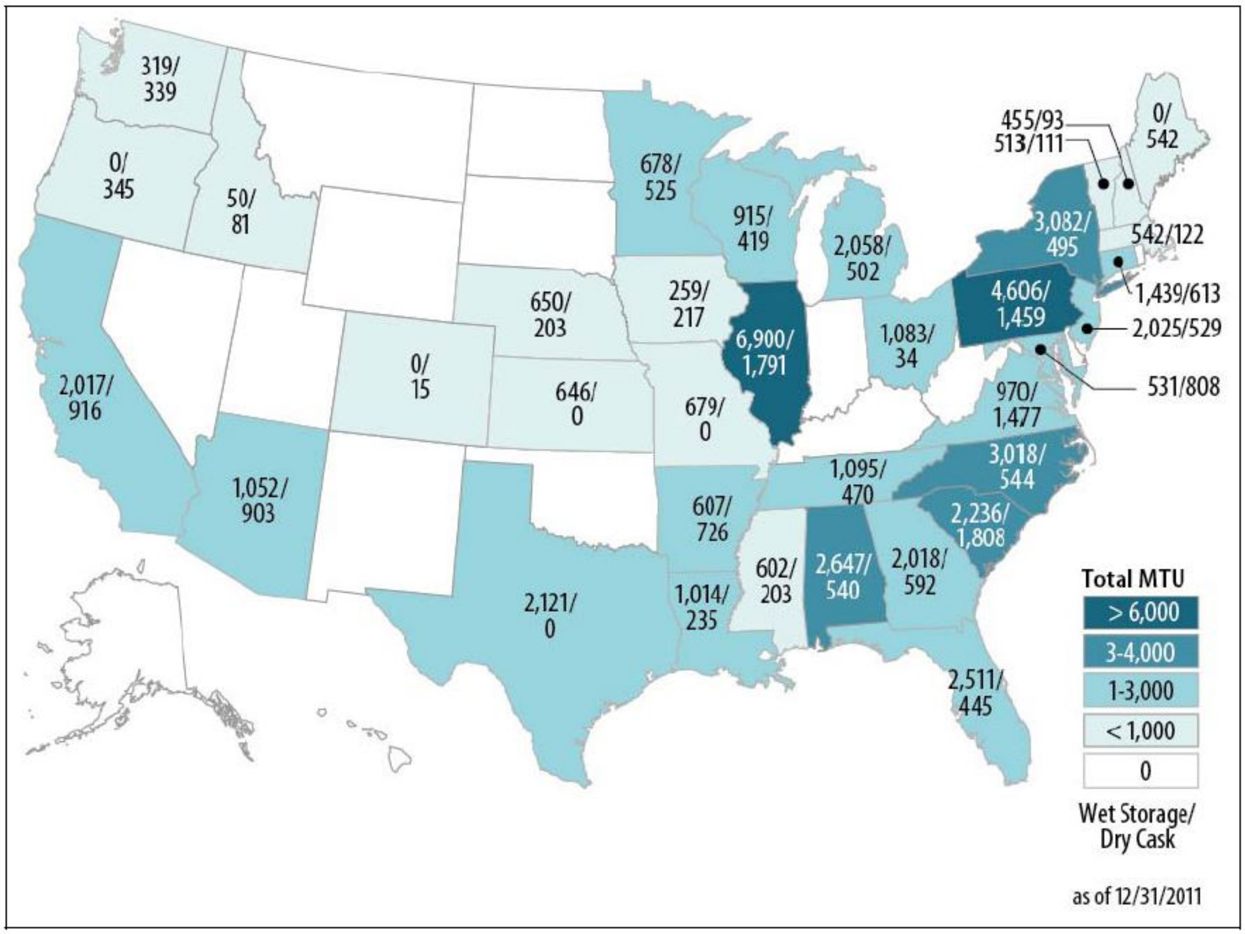
3.5 When the reprocessing option was eliminated in the late 1970s, nuclear plant owners were left with no options other than expanding their onsite spent fuel storage capacities because the repository option was not then—and is still not—available. Low-density storage racks that held

[1] Spent fuel pools were designed and evaluated for protections against loss of water inventory (such as absence of drains and connections below the normal waterline and anti-siphon devices in pipes that enter the pool's volume.) The reactor vessel, and reactor coolant pressure boundary more broadly, are also designed and evaluated for protections against loss of water inventory. But studies are also conducted postulating loss of water inventory anyway to provide assurance that safety system will restore the water level before reactor core damage occurs. Spent fuel pools lack comparable "what if" studies.

irradiated fuel assemblies far apart for protection against inadvertent criticality (i.e., an undesired and uncontrolled nuclear chain reaction) were replaced with high-density storage racks (Lochbaum, 1996). Reracked spent fuel pools can store up to nearly ten reactor cores of spent fuel assemblies.

3.6 As reracked spent fuel pools neared capacity, nuclear plant owners turned to the next method for expanding onsite spent fuel storage capacities—storage in dry casks. Beginning in 1986, owners transferred spent fuel assemblies from their spent fuel pools into dry casks that were stored onsite (NRC 2013d, Appendix P). The transfers to dry cask freed up storage space in the spent fuel pools for discharged from the reactor core during refueling outages.

3.7 As of December 31, 2011, 46,733 metric tons of spent fuel were stored in spent fuel pools across the U.S. and 15,859 metric tons resided in dry casks for a total of 62,592 metric tons. This spent fuel was being stored at 74 individual locations (CRS 2012, Table 1).



(CRS 2012, Figure 5)

These 74 locations were in 35 states. In some states, such as Oregon and Maine, all the spent fuel resided in dry storage. In other states, such as Texas and Missouri, all the spent fuel resided in spent fuel pools. Many other states had spent fuel in both storage methods.

B. NRC's Analysis of Spent Fuel Pool Leaks for its Waste Confidence Draft Generic Environmental Impact Statement

3.8 The NRC developed the WC DGEIS to support a series of proposed findings regarding the safety of spent fuel storage after reactors permanently cease operating. The WC DGEIS also responds to the U.S. Court of Appeals decision that vacated the NRC's Temporary Spent Fuel Storage Rule and Waste Confidence Decision of December 2010 and remanded them back to the agency. According to the NRC, one of the problems found by the Court involved leaks of radioactively contaminated water from spent fuel pools:

> *Related to 60 years of continued storage, the Court concluded that the Commission had not adequately examined the risk of spent fuel leaks in a forward-looking fashion.* (NRC 2013b, page 1-3, lines 19-20)

3.9 In the WC DGEIS, the NRC defined three time periods for continued storage of spent fuel onsite after nuclear power reactors cease operating: short-term (up to 60 years), long-term (up to 160 years including the short-term period), and indefinite. The NRC assumes that spent fuel will be stored in pools only during the short-term period because "decommissioning is normally completed within 60 years after a reactor shuts down" (NRC 2013b, page xxix, lines 28-29). As NRC explains:

> *Spent fuel pools are cooled by continuously circulating water that cools the spent fuel assemblies and provides shielding from radiation. During the short-term storage timeframe, the pools will be used to store fuel until a licensee decides to remove the spent fuel as part of implementing either the SAFSTOR or DECON decommissioning option*. (NRC 2013b, page 2-25, lines 10-13)

3.10 Assuming that spent fuel may be stored in pools for up to 60 years after nuclear power reactors permanently shut down but not for longer periods is supported by existing federal regulation, specifically 10 CFR. §50.82:

> *Decommissioning will be completed within 60 years of permanent cessation of operations. Completion of decommissioning beyond 60 years will be approved by the Commission only when necessary to protect public health and safety.* (NRC 2011a, paragraph (a)(3))

3.11 The assumption of a 60-year storage period in the WC DGEIS is valid because it is backstopped by an existing federal regulation. If an owner wanted to retain spent fuel pool storage for longer than 60 years, 10 CFR. §50.82 would require that owner to obtain the NRC's formal authorization to do so. Because the WC DGEIS only evaluates storage in spent fuel pools for up to 60 years following permanent cessation of reactor operation, no environmental impact study would exist to support spent fuel pool storage beyond 60 years.

3.12 The WC DGEIS concedes a prolonged spent fuel pool leak could cause significant impacts[2] if it was not detected in a timely manner:

> *Public health regulatory limits could be exceeded in the very unlikely event a spent fuel pool leak remained undetected for long periods of time*. (NRC 2013b, page xlii, lines 31-33)
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> ***
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> *For impacts to groundwater resources, though highly unlikely, it is possible that a leak of sufficient quantity and duration could occur, resulting in noticeable impacts to groundwater resources.* (NRC 2013b, page lviii, lines 22-24)
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> ***
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> *If, in the very unlikely event that a pool leak remained undetected for a long period of time, public health regulatory limits (i.e., EPA drinking water standards) could potentially be exceeded.* (NRC 2013b, page lviii, line 34 to page lix, line 1)
>
> ***
>
> *In the very unlikely event that a leak goes undetected and the resulting groundwater plume reaches the offsite environment, it is possible that the leak could be of a sufficient enough magnitude and duration that contamination of a groundwater source above a regulatory limit (i.e., a Maximum Contaminant Level for one or more radionuclide) could occur.* (NRC 2013b, page E-16, lines 18-22)

3.13 However, the WC DGEIS ultimately concludes that it is very unlikely that a spent fuel pool leak will be large enough or last long enough to cause significant impacts; and that even if a large enough or long enough leak occurred, its impacts will be mitigated by hydrological and monitoring programs:

> *The analysis concludes that (1) there is a low probability of a leak of sufficient quantity and duration to affect offsite locations and (2) site hydrologic characteristics and monitoring programs ensure that impacts from spent fuel pool leaks would be unlikely.* (NRC 2013b, page xxxvii, lines 17-20)
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> ***
>
> *In the event of uncontrolled and undetected discharges associated with long-term spent fuel pool leaks to nearby surface waters, the annual discharge would be comparable to normal discharges associated with operating reactors, and would likely remain below limits in 10 CFR Part 50, Appendix I.* (NRC 2013b, page lviii, lines 31-34)

[2] "Significant impacts" is used throughout this declaration in referring to the adverse consequences that could occur if a spent fuel pool leak is not readily detected. Section VIII of this declaration addresses several factors that the NRC apparently fails to consider when evaluating potential significant impacts.

3.14 The conclusion in the WC DGEIS that spent fuel pool leak impacts are insignificant is based on three key assumptions. First, the WC DGEIS assumes that any leak rate greater than 100 gallons per day (gpd) will be readily detected. The NRC explains the basis for this assumption in the WC DGEIS as follows:

> *Based on operational experience, the model leak used for analysis here is assumed to correspond to a leak rate of approximately 380 L/day (100 gpd). … In analyzing the impacts of a spent fuel pool leak, the NRC assumed a leak rate similar to the rate of water lost due to evaporation, which would effectively double the makeup rate to the spent fuel pool. A leak of this magnitude would likely be identified in an expeditious manner because of licensee monitoring and surveillance.* (NRC 2013b, page E-10, lines 9-14)

As discussed in Sections IV, V and VI below, this assumption is flawed because past spent fuel pool leaks suggest that leaks of up to and perhaps greater than 100 gallons per day may not be detected within weeks, months, or even years. Licensees are not even legally required to have functioning spent fuel pool water level instrumentation or groundwater monitoring systems during the 60-year short-term storage period, except during very limited and special situations. In addition, this assumption is not supported by any evaluation showing that leaks smaller than 100 gallons per day would be detected before causing significant impacts.

3.15 Second, the WC DGEIS assumes that:

> *A strong regulatory framework that includes both regulatory oversight and licensee compliance is important to the continued safe storage of spent fuel*. (NRC 2013b, page B-15, lines 27-28)
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>
> *The analyses in this draft GEIS are based on current technology and regulations.* (NRC 2013b, page 1-17, line 21)

As discussed in Section VII below, this assumption is flawed because it relies on regulatory requirements and measures in place for operating reactors without considering the significant reduction in regulatory requirements and oversight that occurs during storage after reactors cease operating.

3.16 Third and last, the WC DGEIS assumes that potential adverse consequences from spent fuel pool leaks will be minimal. As discussed in Section VIII below, this assumption is not valid because the NRC failed to properly consider consequences like property devaluations and remediation costs that could occur when spent fuel pools leak.

IV. THE WC DGEIS FAILS TO FULLY AND PROPERLY APPLY EXPERIENCE FROM PAST SPENT FUEL POOL LEAKS IN ASSESSING FUTURE SPENT FUEL POOL LEAK RISKS

4.1 In the WC DGEIS, the NRC states:

> *Available data and information indicate that spent fuel pool leakage has occurred at the 13 sites listed in Table E-4*. (NRC 2013b, page E-19, lines 25-27)

Table E-4 in the WC DGEIS, reproduced below, lists sixteen reactors at thirteen U.S. nuclear power plants that experienced spent fuel pool leaks.

Table E-4. Occurrence of Spent Fuel Pool Leakage at U.S. Nuclear Power Plants

Site	Date(s) of Leak Discovery	Radioactive Liquid Released to Environment?	Radionuclides Detected
Hatch	December 1986	Yes	Tritium
Indian Point (Units 1 and 2)	August 2005; Unit 1 leakage predates August 2005	Yes	Tritium, nickel-63, cesium-137, strontium-90, and cobalt-60
Palo Verde (Unit 1)	July 2005	Yes	Tritium, cobalt-60, antimony-125, and cesium-137
Salem (Units 1 and 2)	September 2002 (Unit 1) 2010 (Unit 2)	Yes	Tritium
San Onofre (Unit 1)	1986	Yes[(a)]	Tritium, cesium-137
Seabrook	June 1999	Yes	Tritium
Watts Bar (Unit 1)	August 2002	Yes	Tritium and mixed fission products
Crystal River (Unit 3)	2009	No[(b)]	—
Davis-Besse (Unit 1)	2000	No[(b)]	—
Diablo Canyon (Units 1 and 2)	2010	No[(b)]	—
Duane Arnold	1994	No[(b)]	—
Hope Creek	2009	No[(b)]	—
Kewaunee	2007	No[(c)]	—

Sources: NRC 2006b; NRC 2010c; NRC 2010d; Copinger et al. 2012

(a) Contaminated groundwater was discovered during the decommissioning of San Onofre Unit 1. The source of the contaminated water was not clearly identified, but was suspected to have originated from any of three sources, one of which was leakage from the spent fuel pool that occurred from 19861989 (NRC 2010d). Environmental monitoring performed by the licensee subsequent to the leak did not identify radionuclides in the environment attributable to San Onofre (SCE 1995).

(b) Leaked spent fuel pool water was contained within spent fuel pool leakage-collection system.

(c) White boric acid deposits, possibly boric acid, observed on the wall and ceiling of the waste drumming room adjacent to the spent fuel pool.

Only one (Indian Point Unit 1) of these 16 nuclear power reactors was permanently shut down at the time its leaking spent fuel pool was detected. That reactor had two adjacent nuclear power reactors in operation at the time of the discovery. Thus, no site with only permanently shut down reactors has ever identified a leaking spent fuel pool. It's not conclusive whether this means that no pools have leaked or means that leaking pool(s) have not yet been identified.

4.2 The WC DGEIS fails to include at least two important spent fuel pool leak events: the Yankee Rowe nuclear reactor leak and the Brookhaven National Laboratory leak. By omitting these leaks from the WC DGEIS, NRC has failed to consider all past spent fuel pool leaks and formed an inaccurate picture of the potential for future leaks.

A. Yankee Rowe Leak

4.3 The WC DGEIS fails to consider the spent fuel pool leak at the Yankee Rowe nuclear plant in Massachusetts. The Yankee Rowe leak is important because approximately two million gallons of radioactively contaminated water leaked for perhaps as long as three years before it was detected. Some of this radioactive contamination made its way into nearby springs that flow into the Deerfield River.

4.4 The plant's owner reported this leak to the NRC in July 2006 along with other leaks and spills of radioactively contaminated water at the site. The owner's submittal highlighted the spent fuel pool leak:

> *The most noteworthy release that is believed to be the predominant source of tritium in groundwater, occurred between 1963 and 1965 and involved a leak from the Spent Fuel Pool – Ion Exchange Pit structural interface. This leak is estimated to have resulted in the release of over two million gallons of water to the soil. Tritium concentrations exceeding 1,000,000 pCi/L were measured in Sherman Spring at the time of the leak. The spring discharges on licensed property and flows into the Deerfield River.* (YAEC 2006)[3]

4.5 This Yankee Rowe leak resulting in measured tritium concentrations exceeding one million picocuries per liter[4] with flow into a nearby river should have been evaluated by the NRC in the WC DGEIS. The leak was reported to have occurred between 1963 and 1965—indicating a maximum duration of three years and perhaps lasting less than one year. Two million gallons leaking over a three-year period translates into an average leak rate of 1,826 gallons per day.[5] If the duration was two years, the average leak rate was 2,740 gallons per day. If the duration was only one year, the average leak rate was over 5,479 gallons per day. (For this leak rate to have been "only" 100 gallons per day, the leak would have had to span 54 years, 9 months, and 16 days.) In the WC DGEIS, the NRC assumes that spent fuel pool leakage of 100 gallons per day and greater will be readily detected. The Yankee Rowe leak strongly suggests that leak rates far greater than 100 gallons per day can remain undetected for a long time. The WC DGEIS must explicitly identify the regulatory requirements that remain in place during the 60-year short-term storage period that provide reasonable assurance that future leaks similar to the Yankee Rowe leak—or worse—cannot result in significant impacts.

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[3] The owner's report did not indicate whether the water leak from the spent fuel pool or the ion exchange pit or from both places. Regardless, this event demonstrates that radioactively contaminated water can leak at large rates for a long time without being detected—directly contradicting the assumption in the WC DGEIS being challenged in this declaration.

[4] For context, EPA's regulatory limit for tritium in drinking water is 20,000 picocuries per liter.

[5] Calculated by dividing 2,000,000 gallons by 1,095 days.

4.6 By failing to evaluate this Yankee Rowe leak, the NRC has also failed to establish how this leak was detected. If the leak was detected fortuitously rather than by a formal monitoring process, the WC DGEIS should have considered potential impacts had this leak remained undetected for a longer duration.

B. Brookhaven National Laboratory (BNL) Leak

4.7 NRC has failed to consider the longstanding leakage of radioactively contaminated water from the spent fuel pool at the Brookhaven National Laboratory (BNL) on Long Island, New York.[6] The BNL leak is important because a leak went undiscovered for over a decade, despite extensive, focused monitoring and inspection programs. The NRC did not consider the BNL spent fuel pool leak in the WC DGEIS and therefore failed to demonstrate how the factors that contributed to the BNL leak remaining undetected for such a prolonged period could not also allow a larger and/or longer leak from a spent fuel pool during the 60-year short-term period following permanent reactor shutdown.

4.8 According to a 1997 report by the U.S. General Accounting Office, now called the Government Accountability Office, (GAO) found within the NRC's Agencywide Documents Access and Management System (ADAMS):

> *In January 1997, ground water samples taken by BNL staff revealed concentrations of tritium that were twice the allowable federal drinking water standards–some samples taken later were 32 times the standard. The tritium was found to be leaking from the laboratory's High Flux Beam Reactor's spent fuel pool into the aquifer that provides drinking water for nearby Suffolk County residents*. (GAO 1997, page 1)

4.9 The NRC relies on spent fuel pool water level monitoring and groundwater monitoring in concluding in the WC DGEIS that spent fuel pool leaks could not possibly remain undetected for a long period of time. But both these measures failed to prevent such an outcome at BNL:

> *DOE's and BNL's investigation of this incident concluded that the tritium had been leaking for as long as 12 years without DOE's or BNL's knowledge*. (GAO 1997, page 1)

> *Tests conducted after the tritium leak was discovered more accurately accounted for evaporation rates and concluded that the pool was leaking 6 to 9 gallons per day.* (GAO 1997, page 10)

4.10 That the BNL leak remained undiscovered for over a decade clearly illustrates that detection of radioactively contaminated water in monitoring wells or the surrounding soil does not necessarily lead to finding a leaking spent fuel pool. According to the GAO's report:

> *In January 1997, ground water samples taken by BNL staff revealed concentrations of tritium that were twice the allowable federal drinking water standards–some samples*

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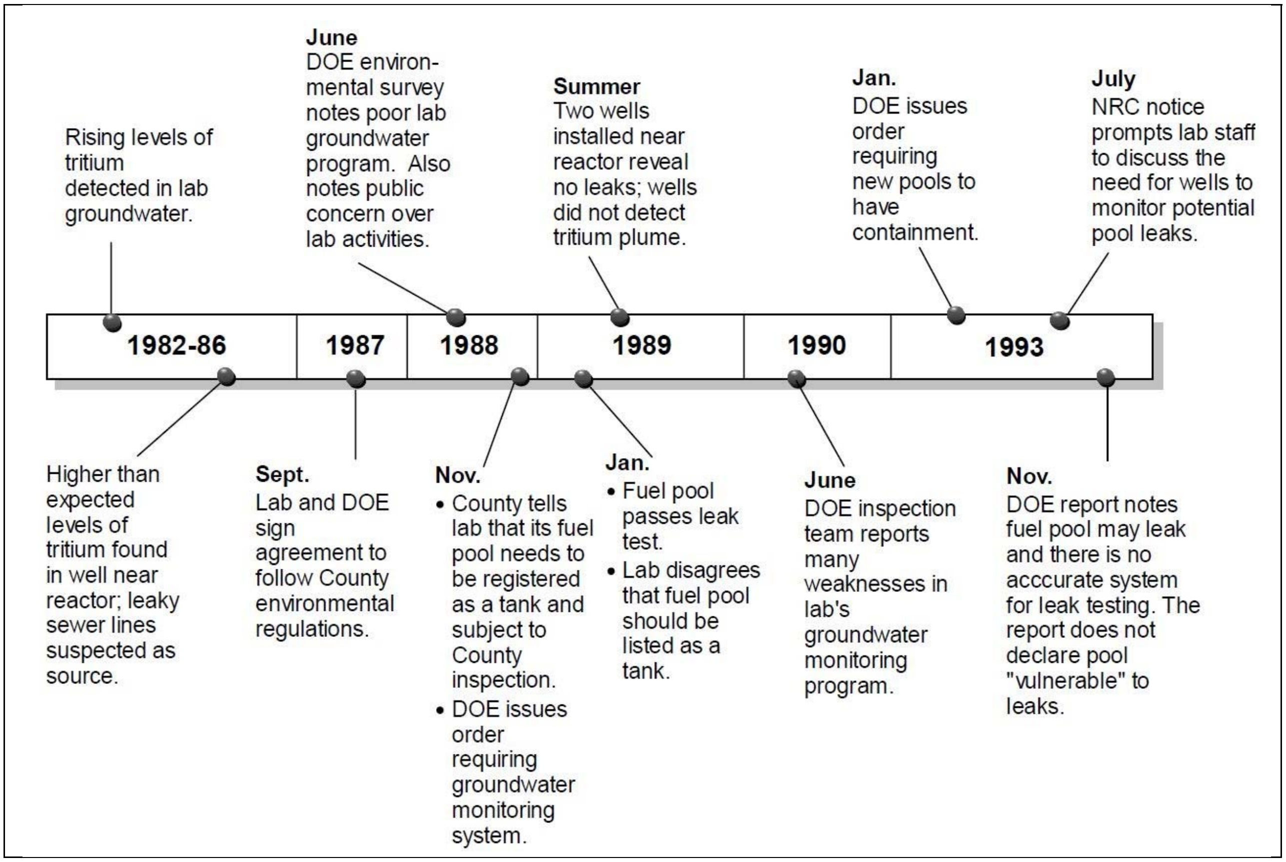
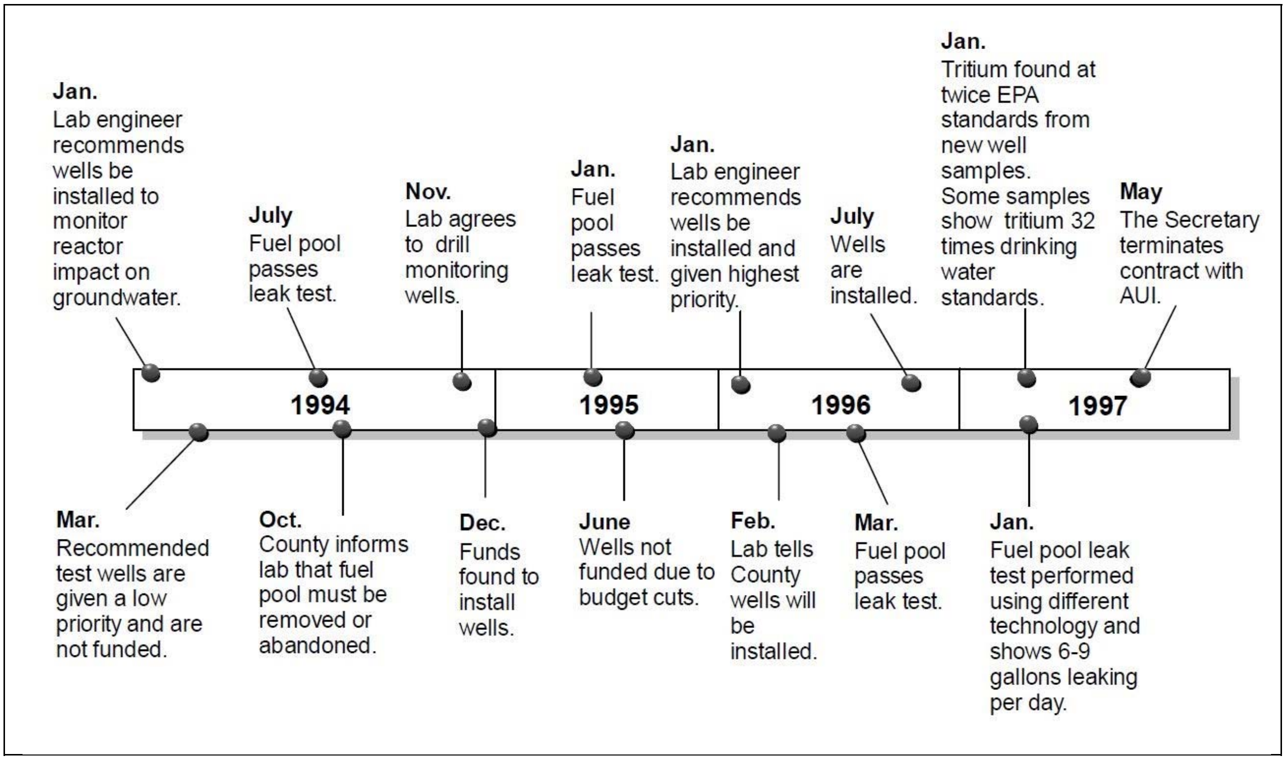
[6] The BNL and its spent fuel pool are not licensed or regulated by the NRC. It is regulated by the U.S. Department of Energy (DOE). But this spent fuel pool leak should be known to the NRC, evidenced by the 1997 GAO report residing within the NRC's electronic library.

> *taken later were 32 times the standard. The tritium was found to be leaking from the laboratory's High Flux Beam Reactor's spent fuel pool into the aquifer that provides drinking water for nearby Suffolk County residents.* (GAO 1997, page 1)

4.11 The following two panels from Figure 1 of the GAO report highlight events occurring between the initial detection of radioactively contaminated water (i.e., tritium) in the soil around BNL and the ultimate discovery of leakage from the spent fuel pool more than a decade later.





4.12 Radioactively contaminated water was detected in monitoring wells during the 1980s, but because the spent fuel pool is not the only potential source of such contamination, it was not considered to be the source:

> *Higher than expected levels of tritium were first discovered in a drinking water well about 500 feet from the reactor in 1986. BNL officials at the time reasoned that the tritium came from local sewer lines and did not suspect the reactor's spent-fuel pool as a source. Sewer lines were a known source of tritium. Tritium originated from condensation that forms inside the reactor building and eventually reached the laboratory's sewer system. No further samples were taken from this well, which was closed because of high levels of other nonradioactive contaminants*. (GAO 1997, pages 7-8)

4.13 Workers tested the spent fuel pool for leaks in January 1989, July 1994, January 1995, and March 1996. Each test concluded was that the spent fuel pool was not leaking. In January 1997, workers conducted a fifth spent fuel pool leak test. This time leakage was detected. These tests were essentially self-fulfilling prophecies, showing no leakage when no leakage was believed to be occurring and finding leakage after monitoring well results suggested leakage was happening.

> *BNL officials acknowledge, in retrospect, that these tests were not carefully conducted because laboratory staff failed to accurately measure the spent-fuel pool's evaporation rate. Tests conducted after the tritium leak was discovered more accurately accounted for evaporation rates and concluded that the pool was leaking 6 to 9 gallons per day*. (GAO 1997, page 10)

> *Using BNL's data as support, a 1993 DOE report noted that the spent-fuel pool was not leaking. The report also noted, however, that there was no reliable means of determining if the spent-fuel pool was leaking*. (GAO 1997, page 8)

4.14 In the summer of 1989, workers installed two additional monitoring wells near the reactor and its spent fuel pool. Samples from these wells did not indicate a leak was in process; not because a leak was not occurring but because they were not in locations to detect an underground plume:

> *BNL officials also relied on well-sampling results to reinforce their position that the spent-fuel pool was not leaking, but these samples did not provide adequate coverage of the area surrounding the reactor where the spent-fuel pool was located*. (GAO 1997, page 10)

4.15 Workers at BNL conducted leak tests of the spent fuel pool and installed monitoring wells to detect radioactively contaminated water leaking into the ground. But rather than causing timely detection of a leaking spent fuel pool, these measures instead gave BNL officials false confidence, and thereby enabled the leakage to continue unabated:

> *Reliance on incomplete tests of water level in the spent-fuel pool and on sample data from monitoring wells scattered around the site led Brookhaven and DOE officials to give low priority to a potential tritium leak.* (GAO 1997, page 2)

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> *To allay the [Suffolk] country's concerns, BNL said that the pool did not leak because it had successfully passed a leak test in 1989. BNL also said that two monitoring wells that were installed in 1989 near the reactor did not indicate any leaking from the reactor's spent-fuel pool. Although BNL officials later told us that the leak test was not accurate and that the two monitoring wells they installed earlier were in the wrong location to detect the tritium contamination, BNL officials relied on these data as the basis for their confidence that the spent-fuel pool did not leak*. (GAO 1997, page 8)

4.16 It is important to recognize that at BNL, a long-term, low-volume leak from the spent fuel pool occurred due to unreliable water level instrumentation, misplaced monitoring wells, and misdiagnosed monitoring well results. This event and its contributing factors cast extreme doubt on the NRC's spent fuel pool leak evaluation in the WC DGEIS:

> *As a result, this evaluation considers a long-term, low-volume undetected leak from a spent fuel pool as the most probable scenario where spent fuel pool leakage would lead to an offsite environmental impact. To go undetected, a leak would need to be less than the fluctuations in water level of a spent fuel pool due to evaporation. This is so because the spent fuel pool water level is constantly measured by instrumentation and monitored routinely by the reactor operators. Also, licensees must perform routine inspections of leak-detection systems and physically inspect the spent fuel pool area for leakage.* (NRC 2013b, page E-10, lines 1-8)

4.17 If the BNL spent fuel pool leaked at 6 to 9 gallons per day for 12 years, then 26,280 to 39,420 gallons of radioactively contaminated water reached the ground before being detected and terminated. This longstanding leak is an important example that NRC should have considered in the WC DGEIS. The WC DGEIS must explicitly identify the regulatory requirements that remain in place during the 60-year short-term storage period that provide reasonable assurance that future leaks similar to the BNL spent fuel pool leak—or worse—cannot result in significant impacts.

C. Salem Leak

4.18 An event at the Salem nuclear plant in New Jersey is a compelling example that an undetected spent fuel pool leak close to the maximum evaporation rate of about 100 gallons per day (gpd) might not be promptly detected. In other words, this event contradicts the conclusion stated in the WC DGEIS that leaks of this magnitude would be promptly detected.

4.19 Like the majority of U.S. nuclear power reactors, the spent fuel pools for Salem's two reactors have reinforced concrete walls and floors. To prevent outward leakage through the porous concrete, each spent fuel pool is equipped with a stainless steel liner. The small space between the liner and the concrete collects spent fuel pool water leaking through the liner. The tell-tale drain routes this water to collection tanks for treatment and then either re-use or release.[7] The tell-tale drain lines became nearly fully obstructed at Salem. Instead of leaking water flowing through the tell-tale drain lines to the collection tank, spent fuel pool water leaked into the space between the stainless steel liner and the concrete. Some of the spent fuel pool water then leaked outward through the concrete. When blockage of the tell-tale drain lines was finally noticed, workers were sent to clean out the lines. When the tell-tale drain line blockage was removed, the measured and indicated leak rate increased:

> *After the cleaning effort [for the tell-tale drains], the leak rate from the tell-tale drain increased from about 19 liters per day (5 gallons a day) to about 380 liters per day (100 gpd).* (NRC 2004, page 2)

4.20 Some, or all, of this 100 gallon per day flow could have been radioactively contaminated water leaking from the spent fuel pool.[8]

4.21 The leak was finally detected when water leaked through a concrete wall and puddled on the floor of an adjacent room. Thus, the leak of up to 100 gallons per day from the Salem spent fuel pool was *not* detected by the spent fuel pool water level instrumentation or the system installed specifically to detect such leakage. (Salem was an operating reactor at the time with hundreds of workers present to limit the amount of time the puddle remained undetected. Had Salem instead been in the short-term storage period, it is less certain that the much smaller work force making far less frequent trips through the permanently closed plant would have found this leak as quickly. The WC DGEIS must explicitly identify the regulatory requirements that remain

[7] In the WC DGEIS (NRC 2013b, page E-19), this is labeled the leak chase system.
[8] It was not reported how much of this flow was attributed to inward leakage of groundwater through the concrete and how much of it was spent fuel pool water outward through the stainless steel liner.

in place during the 60-year short-term storage period that provide reasonable assurance that future leaks similar to the Salem spent fuel pool leak—or worse—cannot result in significant impacts.)

4.22 Making matters worse, the leak detection system at Salem not only failed to promptly detect leakage from the spent fuel pool, it caused that leakage to reach the environment and contaminate surrounding soil. Had the leak detection system not become blocked, water leaking from the spent fuel pool would have flowed through the tell-tale drain lines to a collection tank. The leakage would have been monitored and stored in a tank specifically designed to hold radioactively contaminated water. Instead, the radioactively contaminated water leaked through concrete walls into the neighboring soil.

4.23 The State of New Jersey compelled Salem's owner to remediate the contaminated soil. On February 16, 2005, workers began pumping water out of extraction wells at the Salem site. The campaign was to process this groundwater to remove radioactivity from it, essentially recovering the radioactivity that had leaked from the spent fuel pool. As of September 2011, over 28 million gallons of groundwater had been recovered and processed (Arcadis, 2012). It represents 28 million reasons *not* to believe that spent fuel pool leaks will be detected before causing significant impact.

D. Indian Point leaks

4.24 Leaks from the spent fuel pools at two of the three reactors at the Indian Point nuclear plant in New York are listed in Table E-4 of the WC DGEIS, but their circumstances are not discussed in much detail. As with the other leaks discussed above, the Indian Point leaks contradict the WC DGEIS in important ways.

4.25 The owner of the Indian Point nuclear plant in New York informed the NRC about leakage from the Unit 2 spent fuel pool (SFP) in the 1990s:

> *It is believed that SFP water leaked out of the construction joint at a rate of about 50 gallons per day for about 2 years, leaking into the underlying ground water.* (Entergy 2008)

4.26 Workers inadvertently punctured the stainless steel liner inside the Indian Point Unit 2 spent fuel pool while modifying the storage racks for spent fuel inside the pool. The hole was repaired, but water collected in the space between the liner and the concrete walls and floor of the pool. The plant's owner estimated that approximately 36,500 gallons of radioactively contaminated water flowed from this location to a construction joint (seam) in the concrete. Water leaked past this joint into the soil and "underlying groundwater" (Entergy 2008, page 2).

4.27 This leak remained undetected until another leak from the same spent fuel pool was discovered in 2005. At that time, workers were excavating the ground outside the Unit 2 fuel handling building and noticed moisture forming on the exposed concrete wall. That discovery prompted an investigation that revealed this ongoing leak through the concrete wall and led to the discovery of the earlier leak through the construction joint (Entergy 2008).

4.28 The leak rate of water from the spent fuel pool through the construction joint was estimated to be 50 gallons per day. That leak remained undetected while it was occurring—the leak was only identified and quantified long after the fact. For the WC DGEIS, the NRC assumed that a leak rate of 100 gallons per day would be readily detected. But the NRC failed to evaluate a longstanding leak of less than 100 gallons per day. In other words, if this undetected leakage of 50 gallons per day had continued leaking throughout the 60-year short-term storage period instead of only two years, it might have resulted in significant impacts.

4.29 In addition, according to a recent evaluation by a consultant retained by Indian Point's owner, leakage from the Unit 2 spent fuel pool may be continuing at a rate of between 10 and 30 gallons per day (GZA 2012, footnote 6). If such leakage persists for 60 years, 219,000 to 657,000 gallons will leak. The inability to determine whether past leakage has been stopped also casts considerable doubt on the ability to definitively conclude whether future leakage has started. After all, contamination measured in a groundwater well can easily be attributed to the old source and not initiate an investigation for a new, and perhaps more significant, source.

4.30 Such masking factored heavily into the reactor vessel head degradation near-miss at the Davis-Besse nuclear plant when workers and the NRC misdiagnosed boric acid accumulation on the outer surface of the reactor vessel head as coming from control rod drive mechanism flange leakage, a recurring problem at this site across several years. When later leakage occurred through the control rod drive mechanism itself—a significantly larger potential hazard—the owner and the NRC missed opportunities to detect and correct it in a timely manner. Boric acid accumulation was falsely blamed on the old, recurring benign source instead of to the new, emerging malignant source (NRC 2002).

4.31 The WC DGEIS fails to conclusively show either that smaller leak rates (e.g., less than 100 gallons per day) can be detected in a timely manner or that smaller leaks cannot possibly result in significant impact. The WC DGEIS must explicitly identify the regulatory requirements that remain in place during the 60-year short-term storage period that provide reasonable assurance that future leaks similar to the Indian Point spent fuel pool leaks—or worse—cannot result in significant impacts.

E. Pattern of Not Discussing Causes of Spent Fuel Pool Leaks in the WC DGEIS

4.32 As discussed above for the Salem and Indian Point spent fuel pool leak events, the NRC does not describe in the WC DGEIS how the leakage was ultimately detected. This is also true for all the other spent fuel pool leak events listed on Table E-4 in the WC DGEIS. Obviously, it is also true for the Yankee Rowe and BNL spent fuel pool leak events since the NRC does not mention them at all in the WC DGEIS.

4.33 By failing to explicitly describe how these past spent fuel pool leaks were detected, the NRC also fails to demonstrate how future spent fuel pool leaks would be discovered. In the WC DGEIS, the NRC must explain how past leaks were detected and identify the regulatory requirements that remain in place during the 60-year short-term storage period that provide reasonable assurance that future leaks will be detected.

V. THE WC DGEIS FAILS TO PROPERLY CONSIDER THE DIFFICULTIES INHERENT IN SPENT FUEL POOL LEAK DETECTION

5.1 The NRC's analysis for the WC DGEIS of spent fuel pool leak detection is flawed because it fails to consider the inherent difficulties associated with leak detection and because its 100 gallon per day threshold for effective leak detection lacks solid foundation. The WC DGEIS simply fails to demonstrate that leaks with greater or less than 100 gallons per day will be detected before causing significant impacts.

5.2 The NRC assumes in the WC DGEIS that spent fuel pool leakage equal to the average evaporation rate of water from spent fuel pools would be promptly detected and therefore could be promptly stopped and remediated. The WC DGEIS explains the basis for this assumption as follows:

> *Based on operational experience, the model leak used for analysis here is assumed to correspond to a leak rate of approximately 380 L/day (100 gpd). … In analyzing the impacts of a spent fuel pool leak, the NRC assumed a leak rate similar to the rate of water lost due to evaporation, which would effectively double the makeup rate to the spent fuel pool. A leak of this magnitude would likely be identified in an expeditious manner because of licensee monitoring and surveillance.* (NRC 2013b, page E-10, lines 9-14)

5.3 This assumption is flawed in the following respect. When a spent fuel pool leaks onto the floor or into a surrounding plant area, the puddle formed helps assure timely detection (see paragraph 4.21 of this declaration for such an example). But when a spent fuel pool leaks into the ground, detection becomes more complicated and timely detection less certain (see paragraphs 4.25 to 4.28 of this declaration for such an example). As the NRC noted in a separate study on leaks of radioactively contaminated water into the groundwater:

> *SFP [spent fuel pool] leak detection may require special techniques since SFPs have an evaporation rate up to several hundred gallons per day. This evaporation rate may mask small leaks in the SFP liner and make small leakage rates difficult to detect by evaluation of make-up rates within a water balance calculation.* (NRC 2006a, page 6)

5.4 In the WC DGEIS, the NRC assumes that the spent fuel pool will leak at a rate equal to an evaporation rate of 100 gallons per day. As discussed in paragraph 4.5 of this declaration, the leak rate at the Yankee Rowe plant significantly exceeded 100 gallons per day and yet remained undetected until two million gallons had been released. But the NRC neither lists this reported leak in Table E-4 of the WC DGEIS nor discusses it anywhere within the report. The Yankee Rowe leak undermines—if not totally refutes—the validity of the NRC's assumption that spent fuel pool leaks of 100 gallon per day or greater would be discovered in a timely manner.

5.5 Likewise, potential leakage of 100 gallons per day from spent fuel pool at Salem might not have been detected in a timely manner (see paragraphs 4.19 to 4.21 of this declaration).

5.6 Thus, the WC DGEIS is flawed because the NRC wrongly assumes that spent fuel pool leaks of 100 gpd and larger would be detected and stopped in a timely manner and that the leaked water would pose no significant impacts.

5.7 The WC DGEIS is also flawed because it fails to show that spent fuel pool leak rates of less than 100 gpd will be detected before causing significant impacts. As previously described in paragraphs 4.7 to 4.17 of this declaration, workers eventually discovered that the spent fuel pool at BNL had been leaking at a rate of 6 to 9 gallons per day for over a decade. Four prior spent fuel pool leak tests at BNL failed to properly account for evaporation rates and missed opportunities to detect a leak. And as discussed in paragraph 4.29 above, the Unit 2 spent fuel pool at the Indian Point nuclear plant may still be leaking at 10 to 30 gallons per day.

5.7 The WC DGEIS cannot summarily dismiss that significant impacts might result from spent fuel pool leaks smaller than 100 gallons per day. Instead, the NRC must either (a) show that smaller leaks cannot result in significant impacts even when undetected throughout the 60-year short-term storage period, or (b) identify the regulatory requirements providing reliable assurance that a smaller leak would be detected before it has significant impact. The WC DGEIS cannot merely wish significant impacts away.

5.8 A showing that smaller leaks for prolonged periods cannot result in significant impacts could be made by evaluating potential consequences from the most vulnerable location (i.e., the site where leakage is most likely to have significant impacts due to factors such as the geology, hydrology, population demographics, etc.) against acceptance criteria coupled with confirmatory checks before reactors enter the 60-year short-term storage period that the sites are not more vulnerable. An alternative to this bounding evaluation would be a regulatory requirement that all licensees conduct site-specific evaluations prior to their reactors enter the 60-year short-term storage period.

VI. THE WC DGEIS RELIES ON INCORRECT ASSUMPTIONS ABOUT THE COVERAGE AND APPLICABILITY OF MONITORING REQUIREMENTS

6.1 In concluding that spent fuel pool leaks will be detected in a timely manner, the WC DGEIS relies on the current existence and continuing applicability of a robust set of regulatory requirements for monitoring spent fuel pool water levels and monitoring the groundwater at the site for radioactive contamination, as well as maintenance of spent fuel pools. These assumptions are simply wrong. The requirements are neither robust nor continuing. Even during the more vigilant period of reactor operation, the key requirement on which NRC relies—monitoring of spent fuel pool water levels—applies only in very limited circumstances. And there is no requirement in NRC regulations at all for regular groundwater monitoring during reactor operation and after the reactor permanently shuts down. While the nuclear industry has developed a voluntary groundwater monitoring program, such voluntary measures could be terminated at any time, at the discretion of the industry. And while NRC inspectors have audited the implementation of the voluntary measures at reactors that are presently operating, they did not audit the measures at the reactors that have already permanently shut down and have no stated plans to conduct further audits anywhere. Therefore, the NRC has no basis for relying on these voluntary measures during the 60-year short-term storage period. Thus, a close look shows that the assumption in the WC DGEIS about strong regulatory oversight—an essential underpinning of the NRC's risk and impact prediction for spent fuel pool leaks—is tenuous at best and an illusion at worst.

A. Limited Spent Fuel Pool Water Level Monitoring Requirements

6.2 According to the WC DGEIS, during the short-term storage period:

> *Significant short-term water loss from a spent fuel pool is likely to be identified due to licensee monitoring of spent fuel pool water levels.* (NRC 2013b, page E-9).

But this conclusion is undermined by gaps in the NRC's regulatory requirements governing spent fuel pool water level monitoring.

6.3 When the NRC issues an operating license for a nuclear power reactor, an appendix to the license contains the technical specifications. The technical specifications establish the minimum complement of equipment needed for safety, the testing and inspections required to assure reliability of this equipment, and the remedial measures to be taken when necessary equipment is unavailable.

6.4 The NRC developed Standard Technical Specifications for reactors designed by the different vendors (e.g., Westinghouse, Combustion Engineering, Babcock & Wilcox, and General Electric). Many owners have formally obtained NRC permission to tailor the Standard Technical Specifications to their reactors. In any case, the custom technical specifications for the remaining reactors are comparable in technical content; the primary difference being in the organization and presentation of that technical content.

6.5 The minimum complement of equipment is defined by Limiting Conditions for Operation (LCOs) and applicability statements. For example, an LCO might require two safety pumps to be available when the reactor is operating but only one safety pump when the reactor is shut down.

6.6 LCO 3.7.8 of the NRC's Standard Technical Specifications covers the minimum water level necessary for safety in the boiling water reactors manufactured by General Electric:

> *LCO 3.7.8 The spent fuel pool water level shall be > [23]*[9] *ft over the top of irradiated fuel assemblies seated in the spent fuel storage pool racks*. (NRC 2012b, page 3.7.8-1)

6.7 The associated applicability statement defines when the water level must satisfy this LCO:

> *APPLICABILITY: During movement of irradiated fuel assemblies in the spent fuel storage pool.* (NRC 2012b, page 3.7.8-1)

6.8 Thus, there is a regulatory requirement that the water level be above a certain level in the spent fuel pool *only* when irradiated fuel assemblies are being moved within the pool.

6.9 The reason for this minimum spent fuel pool level and when it is applicable is described in the Bases document developed by the NRC for the General Electric Standard Technical Specifications:

> *BACKGROUND The minimum water level in the spent fuel storage pool meets the assumptions of the iodine decontamination factors following a fuel handling accident*. (NRC 2012c, page B 3.7.8-1)

> *LCO: The specified water level preserves the assumptions of the fuel handling accident analysis. As such, it is the minimum required for fuel movement within the spent fuel storage pool*. (NRC 2012c, page B 3.7.8-1)

> *APPLICABILITY: This LCO applies during movement of irradiated fuel assemblies in the spent fuel storage pool since the potential for a release of fission products exists.* (NRC 2012c, page B 3.7.8-1)

6.10 The minimum spent fuel pool water level requirement protects against radiation released during a fuel handling accident such as when an irradiated fuel assembly drops onto other irradiated fuel assemblies damaging fuel rods and releasing radioactive gases and particles. This exclusive role for the required water level is reinforced by the measures mandated in the Standard Technical Specifications should the requirement not be met:

> *ACTIONS A. Spent fuel storage pool water level not within limit.*

[9] The number in brackets is a convention used within the Standard Technical Specifications to denote a value determined by reactor-specific calculations. For the majority of reactors, the bracketed value will be retained—for some reactor, the site-specific value may be slightly higher or lower as dictated by individual designs.

> *REQUIRED ACTION A.1 Suspend movement of irradiated fuel assemblies in the spent fuel storage pool*. (NRC 2012c, page 3.7.8-1)

6.11 It is, therefore, not required that the water level in the spent fuel pool be restored to above the minimum level or even that a declining water level be halted—all that is required is that the movement of irradiated fuel assemblies within the spent fuel pool be halted.

6.12 For the minimum spent fuel pool water level requirement specified by LCO 3.7.8 to be satisfied, another provision in the Standard Technical Specifications requires that the instrumentation used to measure the level be functional. Specifically, the definition of OPERABLE[10] in Section 1.1, Definitions, of the Standard Technical Specifications states:

> *A system, subsystem, division, component, or device shall be OPERABLE or have OPERABILITY when it is capable of performing its specified safety function(s) and when all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling and seal water, lubrication, and other auxiliary equipment that are required for the system, subsystem, division, component, or device to perform its specified safety function(s) are also capable of performing their related support function(s).* (NRC 2012b, page 1.1-4)

6.13 This definition of OPERABLE applied to LCO 3.7.8 means that REQUIRED ACTION A.1 is invoked whenever the measured water level in the spent fuel pool drops within [23] feet of irradiated (spent) fuel assemblies in the pool's storage racks or whenever the water level instrumentation is unavailable to provide the measured level.

6.14 The relationship between the definition of OPERABLE and the APPLICABILITY statement in LCO 3.7.8 means that the instrumentation used to measure the water level in the spent fuel pool is only required to be available when irradiated (spent) fuel assemblies are being moved in the spent fuel pool. At all other times, the spent fuel pool water level instrumentation can be unavailable (i.e., non-functional) without invoking any out-of-service deadlines or required compensatory actions.

6.15 The NRC's regulatory requirements for water level inside spent fuel pools at pressurized water reactors are comparable:

> *LCO 3.7.15 The fuel storage pool water level shall be $\geq$ 23 ft over the top of irradiate fuel assemblies seated in the storage racks*. (NRC 2012d, page 3.7.15-1)
>
> *APPLICABILITY: During movement of irradiated fuel assemblies in the fuel storage pool.* (NRC 2012d, page 3.7.15-1)
>
> *ACTIONS A. Fuel storage pool water level not within limit.*

[10] The capitalization of this word is a convention used within the Standard Technical Specifications for terms defined within Section 1.1. This convention alerts users to the fact that the terms have explicit meanings.

> *REQUIRED ACTION: Suspend movement of irradiated fuel assemblies in the fuel storage pool.* (NRC 2012d, page 3.7.15-1)
>
> *BACKGROUND The minimum water level in the fuel storage pool meets the assumptions of iodine decontamination factors following a fuel handling accident. The specified water level shields and minimizes the general area does when the storage racks are filled to their maximum capacity. The water also provides shielding during the movement of spent fuel.* (NRC 2012e, page B 3.7.15-1)
>
> *LCO The fuel storage pool water level is required to be ≥ 23 ft over the top of irradiated fuel assemblies seated in the storage racks. The specified water level preserves the assumptions of the fuel handling accident analysis*. (NRC 2012e, page B 3.7.15-1)
>
> *APPLICABILITY The LCO applies during movement of irradiated fuel assemblies in the fuel storage pool, since the potential for a release of fission products exists*. (NRC 2012e, page B 3.7.15-2)

6.16 Limiting the applicability of the minimum water level in the spent fuel pool to only when irradiated fuel assemblies are being moved decreases the likelihood that spent fuel pool leakage will be detected. When these LCOs are not applicable (i.e., when irradiated fuel assemblies are not being moved), it is not required that the instrumentation used to monitor the spent fuel pool water level be in service. Consequently, if the spent fuel pool water level instrumentation broke, there would be no regulatory requirement to return it to service. As a practical matter, under current regulations, the water level instrumentation—and the associated audible, visual, and computer alarms that are generated when water level drops too low—could remain out of service until just before the next planned movement of irradiated fuel assemblies within the spent fuel pool. Because irradiated fuel assemblies are seldom moved within the spent fuel pools, especially within spent fuel pools at reactors that have been permanently shut down, the water level instrumentation could be legally out of service for the overwhelming majority of the time. This reality undermines reasonable assurance that a low-volume spent fuel pool leak would be readily detected.

6.17 In the procedure used when examining spent fuel pools at permanently shut down nuclear power reactors, the NRC inspectors are tasked to:

> *Review and evaluate whether the SFP instrumentation, alarms and leakage detection systems are adequate to assure the safe wet storage of spent fuel.* (NRC 1997, Section 02.02)

6.18 The NRC's Standard Technical Specifications and their Bases define "safe wet storage of spent fuel" as being when at least 23 feet of water exists above the top of the storage racks when irradiated fuel is being moved. When irradiated fuel is not being moved, no regulatory requirement governs the amount of water in the spent fuel pool or the availability of water level instrumentation. Consequently, if an NRC inspector finds the spent fuel pool water level instrumentation out of service or water level inside the pool far below normal, he or she lacks regulatory leverage to compel either condition to be remedied.

6.19 Thus, these LCOs, which are inapplicable during storage because they only apply when spent fuel is being moved, are not supportive of NRC's conclusion that spent fuel pools are being constantly monitored and maintained. The WC DGEIS cannot place much weight on equipment and conditions unless they are required to be in place.

B. Limited Spent Fuel Pool Water Level Record-keeping Requirements

6.20 The NRC presumes in the WC DGEIS that its inspectors will review records such as those prepared by plant workers for tasks like providing makeup water to the spent fuel pool to compensate for evaporation and periodically logging the spent fuel pool water level, and will detect any spent fuel pool leakage (if the workers own efforts have not already discovered leakage). An NRC inspection procedure for examining spent fuel pools at permanently shut down nuclear power reactors appears—at first blush—to support this assumption by stating:

> *The SFP water level instrumentation and alarms should ensure that any significant loss of inventory will be promptly detected by operations personnel. … Operator rounds and control room logs should provide a data base sufficient to identify spent fuel pool leakage problems*. (NRC 1997, Section 03.02)

6.21 As discussed in paragraphs 6.6 to 6.16 of this declaration, however, there are no regulatory requirements in place during the short-term storage period that ensure spent fuel pool level instrumentation will routinely be available. Consequently, the NRC's assumption that routine spent fuel pool water level monitoring and record-keeping will detect spent fuel pool leakage is invalid. Again, the WC DGEIS cannot place much weight on equipment and conditions unless they are required to be in place throughout the 60-year short-term storage period.

C. Nonexistent Spent Fuel Pool Leak Analysis Requirements

6.22 Returning to the procedure used by NRC inspectors when examining spent fuel pools at permanently shut down nuclear power reactors, the NRC states:

> *Within the scope of this inspection, the inspector should evaluate the tests or analytical calculations performed to determine SFP leakage and evaporation rates. The assumptions in these tests and calculations should be assessed and evaluated. For example, a licensee may bound their analyses by a worst-case situation and normalized environmental conditions.* (NRC 1997, Section 03.02)

6.23 But there is no regulatory requirement for licensees to ever calculate spent fuel pool evaporation rates or analyze reasonably foreseeable leakage scenarios. The WC DGEIS states:

> *The safety of spent fuel storage is established for each facility through a safety analysis report prepared by the licensee to support its application for an operating license and review by the NRC. Each safety analysis report includes a number of operational conditions and limitations important to safe spent fuel storage. These conditions and*

> *limitations are subject to regulations that restrict the changes that can be implemented without prior NRC approval.* (NRC 2013b, page E-4, lines 18-22)

6.24 The NRC developed a Standard Review Plan (NUREG-0800) to guide its staff in reviewing safety analysis reports submitted by applicants for reactor operating licenses and determining whether all applicable regulatory requirements have been met. The Standard Review Plan also aides applicants in preparing their submittals to the NRC.

6.25 The spent fuel pool is not the only source of radioactively contaminated water at nuclear power plants. In fact, its water contains significantly lower concentrations of radioactivity than contained in other systems and components. For example, the liquid waste management system (LWMS) collects, stores, and processes highly radioactive liquids. Applicants for operating licenses evaluate the postulated failure of a large LWMS tank that results in most if not all its radioactive contents being released as described in Section 11.6 of the NRC's Standard Review Plan:

> *As a result, a gross failure of the LWMS is considered highly unlikely, e.g., such as a failure involving the near total loss of the system's inventory of radioactive materials. However, the malfunction of a tank and its components, a valve misalignment, tank overflow, or an operator error appear more likely and are assumed to be types of failures warranting an evaluation of their consequences. Although no specific types of system failures have been designated as being representative, it was considered that for the safety evaluation of the LWMS, the type of malfunction analyzed should be limited to the postulated failure of a tank or pipe rupture, located outside of containment. The evaluation considers the impact of the failure on the nearest potable water supply, and the use of water for direct human consumption or indirectly through animals (livestock watering), crops (agricultural irrigation), and food processing (water as an ingredient).* (NRC 2007, page BTP 11-6-2)

6.26 Note that a LWMS tank failure and its potential consequences to the environment are required to be analyzed despite this scenario being "considered highly unlikely" by the NRC.

6.27 The Tennessee Valley Authority evaluated the postulated release of radioactively contaminated water from LWMS tanks at its Browns Ferry Nuclear Plant (BFNP) in Alabama. TVA reported:

> *In order to assess the impact of a liquid radwaste spill on the nearest potable water supply surrounding the BFNP site, a study was conducted to determine if the limits of 10CFR20, Appendix B, Table 2, Column 2 will be exceeded. The results of the study involving a postulated release of liquid radwaste from the worst offending tank indicates that the limits of 10CFR20 will not be exceeded. The worst offending tank identified is the waste collector tank with a maximum operating volume of 38,000 gallons and maximum activity of 1.4E+8 microcuries.*[11] (TVA 2003, page 9.2-7)

[11] 1.4E+8 is scientific notation for 140,000,000.

6.28 TVA reported the results from its study for each LWMS tank in Table 9.2-4 of the Browns Ferry Updated Final Safety Analysis Report (shown below). The table reflects the waste collector tank holding the largest amount of radioactivity, thus posing the greatest hazard.

BFN-18

Table 9.2-4
(Sheet 1)

RADIOACTIVITY CONTENTS OF TANKS AND SYSTEMS NOT DESIGNED TO WITHSTAND TORNADO, MAXIMUM PROBABLE FLOOD OR DESIGN BASIS EARTHQUAKE

		Maximum Activity Per Tank or System (µCi)	Isotopic Distribution, Percent of Total Activity (b)													
Vessel or System Name	Number of Tanks	Total	Sr-89	Sr-90	Sr-91	Mo-99	1-131	1-133	1-135	Cs-134	Cs-137	Ba-140	Ce-144	Np-239	CO-58	CO-60
Waste Surge Tank	1	2.3×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Waste Sample Tank	4	2.1×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Floor Drain Sample Tank	2	1.2×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Laundry Drain Tank	2	3.6×10^4	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Waste Collector Tank	1	1.4×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
**Floor Drain Collector 1 Tank	9.5×10^6	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1	
Cleanup Backwash Receiver Tank (a)	3	5.0×10^9	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Condensate Backwash Receiver Tank (a)	3	1.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Spent Resin Tank (a)	1	2.0×10^9	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Waste Backwash Receiver Tank (a)	1	2.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Chemical Waste	1	1.4×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Condensate Storage Tank	5	2.0×10^6	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Condensate Transfer System	-	6.0×10^4	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Condensate Filter/ Demineralizer Tanks (a)	27	1.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Fuel Pool Filter/ Demineralizer Tanks (a)	4	2.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Waste Demineralizer Tank (a)	1	3.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Evaporator Feed Tank	1	5.0×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Waste Filter Tank (a)	1	1.0×10^8	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1
Floor Drain Filter Tank (a)	1	9.0×10^5	0.7	0.2	8.6	18.3	8.6	14.3	6.4	0.1	0.2	18.3	0.1	18.6	1.0	0.1

6.29 Studies of postulated releases from LWMS tanks serve two important purposes. First, the results demonstrate compliance with federal regulations on discharges of radioactivity to the environment. Second, they define the boundaries for future plant activities.

6.30 As discussed in paragraphs 3.2 to 3.4 above, postulated losses of water inventory from the reactor vessel must be postulated and evaluated, regardless of the low likelihood of occurrence. As discussed in paragraphs 6.25 to 6.28 above, postulated losses of water inventory from LWMS tanks must be postulated and evaluated, again regardless of their likelihood. These evaluations define the respective hazards that federal regulations require protection against. Their results essentially form the answer keys when determining whether a reactor's design and procedures comply with federal regulations. Their results also establish boundaries for subsequent reactor operation. Before a license modifies the plant or revises its procedures, 10 CFR §50.59, Changes, tests and experiments, requires that the proposed activity be evaluated against the established boundaries. If an activity significantly increases the consequences or likelihood of a previously evaluated event, it cannot happen unless the NRC explicitly approves it.

6.31 Neither the NRC's Standard Review Plan nor any of the literally dozens of safety analysis reports submitted by plant owners analyze either a long-term, low-volume leak from a spent fuel pool or the rapid and complete loss of spent fuel pool water into the environment. The failure to analyze a spent fuel pool leak means that neither of the two purposes described in paragraphs 6.29 and 6.30 above is met. First, because the hazard is not defined, the adequacy of purported protective measures intended to manage the risk cannot be objectively assessed. Second, because a hazard evaluations results are not available to establish boundaries, there is no assurance that adequate protection will be sustained throughout the 60-year short-term storage period.

6.32 To illustrate the necessary role performed by hazard evaluations, consider a hypothetical case in which a spent fuel pool leak was postulated and evaluated. Suppose the results from that evaluation showed that a leak of up to X gallons per day could not cause significant impacts and that a leak of X gallons per day or greater could not cause significant impacts as long as it was detected within Y days. These results define how much water could be released via what specific pathways to facilitate objective determination whether NRC and EPA radiation protection standards will be met.

6.33 The results from the hypothetical hazard evaluation described in paragraph 6.32 above establish boundaries that provide assurance that risk continues to be properly managed into the future. For example, suppose the basis for concluding that leaks of up to X gallons per day not resulting in significant impacts relied on the combination of migration time required for leaked water to reach a source of drinking water and the filtering of radionuclides from the plume before it reached that source. The subsequent discovery that leaked water could enter an underground conduit and reach a drinking water source, effectively bypassing the delay and filtering functions of the geology/hydrology, would necessitate a re-evaluation to determine if the study's conclusion remained valid or required revision. As another example, suppose the means of detecting the X gallons per day or larger leak within Y days relies on weekly sampling from a close-in groundwater monitoring well. Before the frequency of sampling this well was relaxed to monthly or before this well was removed from service and replaced by a well three times more distant, an evaluation would need to conclude that a leak of X gallons per day or greater will still be detectable within Y days—otherwise, proper management of the risk of significant impacts is invalidated.

6.34 Absent the proper foundation afforded by a hazard evaluation, it is speculative to conclude that spent fuel pool leaks of 100 gallons per day will be detected before causing significant impacts. And even if such speculation was valid today, the conditions enabling that conclusion to remain valid throughout the short-term period are not explicitly defined. Consequently, owners could inadvertently undermine its validity by taking steps such as relaxing sampling frequencies, relocating wells, or removing water level instrumentation.

6.35 Risk management requires a hazard and its protections to both be defined as explicitly as possible. Doing so enables the risk to be properly managed now and into the future. By explicitly defining the hazard, one can determine when changing conditions increase the hazard, thus allowing protection levels to be increased accordingly. By explicitly defining protections credited against the hazard, one can make informed decisions whether proposed changes to the protections retain the necessary safety margins.

6.36 But there is simply no regulatory requirement that licensees analyze a postulated leak of any rate (small, medium, or large) of radioactive water from the spent fuel pool for any duration (short or long) for its postulated consequences to the environment. Neither the spent fuel pool leak hazard nor protections against it are explicitly defined. The conclusions expressed in the

WC DGEIS that spent fuel pool leaks will be detected before causing significant impacts are therefore speculative and subjective.

6.37 In addition, the WC DGEIS provides no argument that a spent fuel pool leak is more "highly unlikely" than a LWMS tank failure. In fact, the WC DGEIS is silent regarding the relative likelihood of these two scenarios. Yet LWMS tank leaks must be analyzed for its potential consequences to the environment while spent fuel pool leaks need not. This discrepancy is not justified.

D. Nonexistent Groundwater Monitoring and Inspection Requirements

6.38 The NRC in the WC DGEIS assumes that leaks of 100 gallons per day and greater from the spent fuel pool will be readily detected, corrected, and mitigated to prevent significant impacts. The NRC further assumes that groundwater monitoring will back up in-plant leakage detection processes so as to detect spent fuel pool leaks before significant impacts occur:

> *In addition to spent fuel pool design and operational controls, licensees are required, as described in Section E.1.2, to perform groundwater monitoring at nuclear power plant sites, which makes it unlikely that leakage from the spent fuel pool would remain undetected long enough for any contamination to migrate offsite. In addition, a groundwater-monitoring program based on a site characterization that conforms to standards (e.g., ANSI/ANS 2.17–2010) and a configuration of monitoring wells that takes into account the most likely leakage pathway (i.e., the spent fuel pool) would further reduce the likelihood that a leak would remain undetected long enough for contamination to migrate offsite.* (NRC 2013b, page E-10, lines 15-22)

6.39 The foundation for this WC DGEIS assumption exists in the procedure used by NRC inspectors when examining spent fuel pools at permanently shut down nuclear power reactors:

> *The inspector should also review data from the licensee's environmental monitoring program, if applicable, to determine if there are indications of SFP leakage into the environment*. (NRC 1997, Section 03.02)

6.40 But the environmental monitoring program is an illusion. There are no regulatory requirements for groundwater monitoring either at operating reactors or reactors during the 60-year short-term storage period:

> *Existing NRC regulations do not explicitly mandate routine onsite ground-water monitoring in the Restricted Area during facility operations*. (NRC 2006a, page 5)

6.41 Although the WC DGEIS cites a recent Decommissioning Planning Rule that "requires all licensees to establish operational practices to minimize site contamination and perform reasonable subsurface radiological surveys" (NRC 2013b, page B-18, lines 17-18), in reality the rule allows licensees to choose whether or not to conduct groundwater monitoring:

> *The amendments in this final rule require licensees, to the extent practical, to conduct their operations to minimize the introduction of residual radioactivity into the site, particularly in the subsurface soil and groundwater. There are a variety of monitoring methods to evaluate subsurface characteristics, and these are highly site specific with respect to their effectiveness. One or more licensees <u>may find</u> that compliance with the amendments will mean the installation of groundwater monitoring wells and surface monitoring devices at their sites.* (Federal Register 2011, page 35561) (emphasis added)

6.42 Rather than enforceable, reliable, dependable regulatory requirements, the WC DGEIS instead relies on a voluntary industry program for groundwater monitoring:

> *For nuclear power plants licensed before August 20, 1997, which includes all currently operating reactors, NRC has found that, in general, groundwater monitoring conducted in accordance with the Groundwater Protection Initiative developed by the Nuclear Energy Institute, a nuclear industry consortium, is adequate to comply with these regulations. … However, licensees may choose to develop groundwater-monitoring programs with additional elements than those recommended by the Groundwater Protection Initiative. For nuclear power plants licensed after August 20, 1997, licensees are subject to the additional requirements of 10 CFR 20.1406(a)-(b), of which "monitoring and routine surveillance programs are an important part of minimizing potential contamination".* (NRC 2013b, page E-5, lines 38 to page E-6, line 9)

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> *The Nuclear Energy Institute developed its Groundwater Protection Initiative in 2006 in response to leaks containing radioactive material at several plants. The initiative is described in NEI 07-07, "Industry Ground Water Protection Initiative – Final Guidance Document"... All power reactor licensees have committed to follow the initiative, which identifies actions to improve licensee response to inadvertent releases, including releases from spent fuel pools that may result in low, but detectable, levels of plant-related radioactive materials in subsurface soils and water.* (NRC 2013b, page E-6, lines 10-16)

6.43 But the NRC's reliance on such voluntary measures directly contradicts NRC's conclusion that:

> *A strong regulatory framework that includes both regulatory oversight and licensee compliance is important to the continued safe storage of spent fuel*. (NRC 2013b, page B-15, lines 27-28)

6.44 The NRC's insistence on a strong regulatory program as the basis for its environmental findings is reasonable. The industry's Groundwater Protection Initiative is a voluntary measure that may be retracted or relaxed by the nuclear industry at any time without NRC review and approval. In addition, as discussed below in Section VII, it is currently not being routinely inspected by the NRC at either operating or permanently shut down nuclear power plants. As such, the WC DGEIS cannot credit this non-mandatory, non-inspected program with detecting and correcting leaks during the 60-year short-term storage period.

VII. THE WC DGEIS FAILS TO ACCOUNT FOR THE SIGNIFICANT REDUCTION IN REGULATORY REQUIREMENTS AND OVERSIGHT THAT OCCURS AFTER A REACTOR CEASES OPERATION

7.1 In reaching its conclusion that spent fuel leaks cannot have significant impacts, the WC DGEIS assumes the continued effectiveness of current monitoring requirements, oversight procedures, and other measures that are in place while the reactor is operating, rather than looking ahead to the fewer requirements, procedures, and other measures that will remain in place after reactors permanently shut down. As stated in the WC DGEIS:

> *For the purposes of the analyses in this draft GEIS, the NRC assumes that regulatory control of radiation safety will remain at the same level of regulatory control as currently exists today*. (NRC 2013b, page 1-15, lines 3-5)

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> *The analyses in this draft GEIS are based on current technology and regulations.* (NRC 2013b, page 1-17, line 21)

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> *Even though the reactor is no longer operating during the short-term storage timeframe, a licensee is still bound by the terms and conditions of its operating license until the license is terminated. As a result, the NRC assumes that spent fuel pool maintenance requirements that are in place during the operating period of the reactor will remain in place during the short-term timeframe and will stay in place even if the license is modified during the short-term timeframe.* (NRC 2013b, page E-4, lines 13-17)

7.2 This assumption is blatantly wrong. There is extensive evidence that the scope of regulatory requirements and associated regulatory oversight significantly shrinks after a nuclear power reactor permanently shuts down. This declaration presents some examples, although much more evidence exists.

7.3 For instance, standard NRC communications with licensees about safety problems and concerns are typically not sent to licensees of permanently shut down reactors, even when they contain relevant information. On March 3, 2004, the NRC issued Information Notice 2004-05 regarding the leak from the spent fuel pool at Salem that reached the soil. The NRC sent this warning notice to:

> *All holders of operating licenses for nuclear power reactors (except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel)* (NRC 2004, page 1)

7.4 Owners of reactors that have permanently shut down nuclear power reactors and who have certified to the NRC that all irradiated fuel has been removed from the reactor vessel did not formally receive the warning from the NRC about spent fuel pool leakage. If information is power, the NRC leaves these owners powerless to prevent similar leaks from their spent fuel pools.

7.5 The NRC's failure to send such warnings to owners of permanently shut down reactors has implications beyond merely keeping individual storage sites in the dark. Operating experience programs adopted throughout the nuclear power industry in the wake of the March 1979 accident at Three Mile Island are used to review incoming correspondence such as NRC's Information Notices and screen them for applicability to the site. Applicable documents are routed to appropriate departments for review and action. Applicable documents are thus formally incorporated into training programs and procedures. But the NRC's decision to exclude owners of permanently shut down nuclear power reactors about a spent fuel pool leakage problem robs them of the operating experience opportunity to capture this information in appropriate in-plant procedures and programs—the very procedures and programs the NRC improperly takes full credit for in the WC DGEIS.

7.6 The NRC also fails to require licensees of permanently shut down reactors to implement safety upgrades, even those upgrades directly related to spent fuel pool safety. For instance, on March 12, 2012, the NRC issued three orders requiring licensees to implement lessons it learned from the March 2011 accident at Fukushima in Japan. One of the orders issued that day required the installation of reliable instrumentation to monitor the water level inside spent fuel pools:

> *The lack of information on the condition of the spent fuel pools contributed to a poor understanding of possible radiation releases and adversely impacted effective prioritization of emergency response actions by decision makers.* (NRC 2012f, attachment 1, page 3)

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> *During the events in Fukushima, responders were without reliable instrumentation to determine water level in the spent fuel pool.* (NRC 2012f, attachment 1, page 6)

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> *…the Commission has determined that all power reactor licensees and CP [construction permit] holders must have a reliable means of remotely monitoring wide-range spent fuel pool levels to support effective prioritization of event mitigation and recovery actions in the event of a beyond-design-basis external event.* (NRC 2012f, attachment 1, page 7)

7.7 This NRC order to install reliable spent fuel pool water level instrumentation was issued to:

> *All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status* (NRC 2012f, page 1)

7.8 A search performed on August 27, 2013, of ADAMS, the NRC's online electronic library of publicly available agency records, failed to identify any such order issued by the NRC on or after March 12, 2012, for the permanently shut down Zion nuclear power reactors.

7.9 The NRC confirmed its intention not to impose these safety upgrades on permanently shut down reactors after the Crystal River Unit 3 reactor in Florida shut down in early 2013. Its owner had received the March 2012 order from the NRC to install reliable spent fuel pool water level instrumentation. The owner asked the NRC to rescind the order because the reactor would not resume operation (Duke 2013). The NRC granted the request and approved the removal of (or lack of installation of) reliable spent fuel pool instrumentation from this permanently shut down reactor (NRC 2013c).

7.10 After the Kewaunee reactor in Wisconsin shut down later in 2013, its owner also requested that the NRC rescind its order requiring reliable spent fuel pool water level instrumentation to be installed (Dominion 2013).

7.11 Another example of the regulatory requirement shrinkage involves groundwater monitoring. According to the WC DGEIS:

> *In April 2011, the NRC evaluated industry performance in "Summary of Results from Completion of NRC's Temporary Instruction on Groundwater Protection, TI-2515/173 Industry Groundwater Protection Initiative." ... This report was based on inspections conducted between August 2008 and August 2010 at all nuclear power plant sites.* (NRC 2013b, page E-7, lines 1-4)

7.12 The WC DGEIS is correct that TI-2515/173 was written to apply to <u>all</u> nuclear power reactors:

> *This Temporary Instruction (TI) applies to all holders of operating licenses for nuclear power reactors, including those plants which have permanently ceased operations.* (NRC 2008)

7.13 But the statement in the WC DGEIS that NRC's report was based on inspections of groundwater monitoring "at all nuclear power plant sites" is patently false. Instead, inspections were only performed at <u>some</u> nuclear plants sites; namely, the sites with operating nuclear power reactors. Sites with only permanently shut down nuclear power reactors were <u>not</u> inspected between August 2008 and August 2010 as is clearly evident from Tables 1, 2, 3, and 4 from NRC 2008 found in Appendix A.

7.14 These tables clearly show that, while the NRC inspected the voluntary programs implemented under the Groundwater Protection Initiative at operating nuclear power plants, it did not inspect the programs implemented at permanently shut down plants like Zion and Humboldt Bay.[12] The WC DGEIS cannot place weight on voluntary measures that have never been inspected by the NRC.

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[12] A search of the NRC's ADAMS library on August 29, 2013, failed to produce any publicly available records indicating that the NRC had, or plans to, conduct groundwater protection initiative inspections using the Groundwater Protection Initiative, TI-2515/173, at permanently shut down nuclear power reactors.

7.15 Regarding its inspections at operating nuclear power plants that someday will permanently shut down, the NRC's position is that:

> *Licensees that have implemented a groundwater monitoring program consistent with the Nuclear Energy Institute Groundwater Protection Initiative are considered to have an adequate program for the purposes of the Decommissioning Planning Rule.* (NRC 2013b, page 3-10, line 37 to page 3-20, line 1)

7.16 Based on the successful results from the one-time Groundwater Protection Initiative inspection at operating nuclear power plants, the NRC apparently considers the voluntary groundwater monitoring program to be adequate over the entire 60-year short-term storage period at shutdown plants in the WC DGEIS. This assumption is illogical and contrary to the NRC's experience periodically inspecting mandatory—not voluntary—regulatory requirements at operating nuclear power plants.

7.17 The industry's Groundwater Protection Initiative is a voluntary measure that is currently not being routinely inspected by the NRC at either operating or permanently shut down nuclear power plants. As such, the WC DGEIS cannot credit this non-mandatory, non-inspected program with detecting and correcting leaks during the 60-year short-term storage period.

7.18 Further evidence of lessened regulatory oversight after a reactor permanently shuts down is provided by the NRC's Reactor Oversight Process (ROP). Under the ROP, the NRC conducts routine and reactive inspections at operating nuclear power plants to verify compliance with regulatory requirements or identify non-compliances warranting correction. Appendix B lists the ROP's baseline inspection procedures and the associated frequencies with which they are conducted. The baseline inspections examine a wide range of areas, from fire protection to radiation protection to maintenance to security, over a three-year period. The NRC conducts some baseline inspections every quarter. The least frequent baseline inspection is conducted at least once every three years.

7.19 Recent ROP inspection results as posted on the NRC's website on August 28, 2013, are contained in Appendix C. The numerous green, white, yellow, red, and greater-than-green inspection findings clearly demonstrate that plant owners do not always comply with regulatory requirements, even in areas routinely examined by NRC inspectors. All results labeled with any colored box indicate noncompliance with regulatory requirements. The NRC cannot assume in the WC DGEIS that owners will conform to voluntary measures (such as the Groundwater Protection Initiative) when their track record demonstrates repetitive non-compliance with mandatory regulatory requirements.

7.20 Similarly, the scope of the Maintenance Rule—on which the NRC relies for its finding of no possibility of significant impact (see WC DGEIS, page E-5, lines 1-13)—shrinks after a nuclear reactor permanently shuts down. Decades ago, the NRC promulgated the Maintenance Rule to establish regulatory requirements for maintenance and testing of safety related components (NRC 1991). But the rule does not provide protection against spent fuel pool leaks:

> *The maintenance rule, 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," requires monitoring the performance or condition of structures, systems, or components (SSCs). For licensees who have submitted the certifications for cessation of operation and for permanent fuel removal specified in 10 CFR 50.82(a)(1), this section applies only to the extent the licensee monitors the performance or condition of the SSCs associated with the storage, control, and maintenance of spent fuel in a safe condition and in a manner sufficient to provide reasonable assurance that such SSCs are capable of fulfilling their intended functions (see 10 CFR 50.65(a)(1)).* (NRC 2000, page 1.184-12)

7.21 As described in paragraphs 6.3 to 6.15 of this declaration, the safety analysis reports and technical specifications establish "spent fuel in a safe condition" as entailing protection against a fuel handling accident. The safety analysis reports and technical specifications do not impart protection against long-term, low-volume leaks from the spent fuel pool as part of "spent fuel in a safe condition." Thus, licensees can and do legally omit structures, systems, and components needed to detect and mitigate spent fuel pool leaks (e.g., water level instrumentation, water makeup pumps, leakage detection systems, etc.) from the scope of their maintenance rule programs. The WC DGEIS simply cannot take credit for measures its regulations allow licensees to remove. The WC DGEIS must only credit measures that regulations compel licensee to retain.

A. Zion – A Case Study

7.22 The permanently shut down nuclear power reactors at the Zion nuclear plant in Illinois illustrate regulatory requirement shrinkage:

> *In March 1998, Com Ed certified per 10CFR50.82 that the company had permanently ceased power operation and that all fuel was in the Spent Fuel Pool. This is a permanent, non-revocable certification that changed the Zion Station licensing basis.* (ComEd 1998, attachment B, page 1)
>
> ***
>
> *The most significant effect of this licensing basis change was to eliminate nuclear safety functions for the majority of the structures, systems, and components (SSC's). Those SSC's, which had only performed a reactor safety function (i.e., SSC's that do not support spent fuel or radiation protection function), need no longer be maintained under nuclear grade controls.* (ComEd 1998, attachment B, page 1)

7.23 The scope of maintaining "spent fuel in a safe condition" at Zion was also redefined to narrow its scope:

> *Radioactive Release from a Subsystem or Component: All accidents, with the exception of the Fuel Handling accident in the Fuel Building, were deleted. … Added section with new accident analyses for Spent Fuel Pool Accident, loss of Spent Fuel Pool Cooling, and HIC Drop Accident.* (ComEd 1998, attachment B, page 15)

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> *However, two aspects of the pool design would allow the inventory to be significantly reduced in the event of a failure. These are,*
>
> 1. *A seal failure of a fuel transfer canal removable weir gate, and*
> 2. *A rupture of the spent fuel cooling water pump return line.* (ComEd 1998, page 5-4)

7.24 Any worker or NRC inspector seeking to ascertain whether "spent fuel in a safe condition" is reasonably assured at Zion need only evaluate whether protections against a fuel handling accident and a significant reduction in spent fuel pool water inventory are adequate. As described in VI of this declaration, protection against a fuel handling accident is defined to be maintaining the water level at least 23 feet above the spent fuel storage racks when irradiated fuel assemblies (or the HIC cask) are being moved; otherwise, any spent fuel pool water level is acceptable. As described in ComEd 1998, protection against a significant reduction in spent fuel pool water inventory involves the fuel transfer canal's weir gate seal and the spent fuel pool cooling water pump discharge piping. Protection against a long-term, low-volume spent fuel pool leak is neither directly nor indirectly associated with these regulatory requirements.

7.25 The WC DGEIS cannot credit regulatory requirements that are entirely silent on the matter to provide protection against long-term, low-volume spent fuel pool leaks during the 60-year short-term storage period.

B. Dresden – A Case Study

7.26 Dresden Unit 1 in Illinois provides another important example of the breakdown in monitoring programs and regulatory oversight after reactors permanently shut down. This example undermines the NRC's assumption stated in the WC DGEIS that:

> *Even though the reactor is no longer operating during the short-term storage timeframe, a licensee is still bound by the terms and conditions of its operating license until the license is terminated. As a result, the NRC assumes that spent fuel pool maintenance requirements that are in place during the operating period of the reactor will remain in place during the short-term timeframe and will stay in place even if the license is modified during the short-term timeframe.* (NRC 2013b, page E-4, lines 13-17)

7.27 The NRC is, or should be, aware of past events such as that at Dresden rendering this assumption tenuous at best, outright invalid at worst. On January 25, 1994, workers discovered about 55,000 gallons of water on the floor of the basement of the reactor building for the Unit 1 reactor at the Dresden nuclear plant in Illinois. Its owner had permanently shut down the reactor on October 31, 1978. The NRC dispatched a special inspection team to Dresden to investigate this event. The NRC's team discovered (NRC 1994a):

- The owner stopped providing heating for the reactor building in 1989. The lack of heating led to cold temperatures inside the building that froze the water inside a pipe of the service water system causing it to burst. Leakage from this ruptured pipe was found on the basement floor. The lack of heating could also have frozen and ruptured the fuel transfer tube, allowing the spent fuel pool water to drain down and expose the top several feet of irradiated fuel in the storage racks. Had this occurred, the drained water would have reduced shielding and created high radiation levels onsite.

- The owner had turned off the spent fuel pool cooling and cleanup system in 1983. By 1987, the water quality inside the spent fuel pool degraded to the point where an influx of microorganisms had developed. Records showed that the conductivity of the spent fuel pool water was two times the limit in the operating license.

- The poor quality of the spent fuel pool water could have adversely affected the seating surfaces and gaskets for the spent fuel pool gate.

- The owner had no spent fuel pool leak detection program, nor did the owner have a water inventory program that might have detected leakage from the spent fuel pool via increased makeup additions to it.

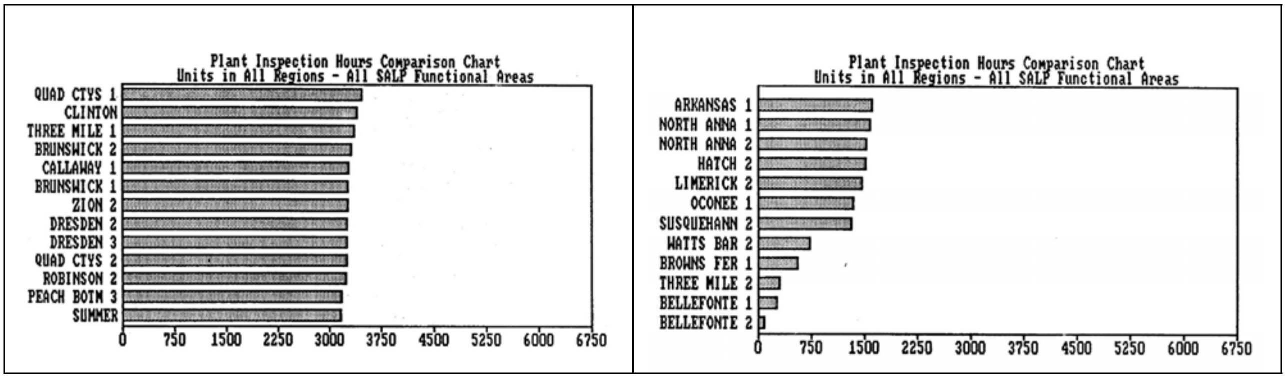
7.28 According to the NRC:

> *The inspection team concluded that the layup of the plant and storage of spent fuel at Dresden 1 was not well managed or maintained for a period of years and that weaknesses existed in the site quality audit and inspection programs. Further, safety reviews of changes to Dresden 1 systems such as termination of heating and ventilation for the containment were apparently not performed or not adequately reviewed to determine the safety consequences of the changes. Interviews with personnel at the Dresden site (which includes two operating units in addition to Dresden 1) showed that, in part, the weaknesses identified above were based on an incorrect belief that Dresden 1 could not cause a serious safety problem because it was permanently shut down. This belief resulted in audits and safety evaluations that were not rigorously implemented or that did not include the Dresden 1 systems and programs.* (NRC 1994a, page 3)

The NRC imposed a $200,000 civil penalty on the plant's owner for this event (NRC 1994a).

7.29 This event exposes the reality that the NRC's WC DGEIS fails to address the significant reduction in regulatory requirements that occurs after a reactor permanently shuts down. The NRC assumes in the WC DGEIS that all spent fuel pool maintenance measures will apply and be met during the short-term storage period. Yet, the NRC fined the owner of Dresden Unit 1 for inappropriate actions like turning off the spent fuel pool cooling and cleanup system 12 years prior to this event and allowing the water quality inside the spent fuel pool to violate operating license requirements for many years. The WC DGEIS is deficient by assuming this event is isolated and never to be repeated and not identifying reliable means to prevent recurrence.

7.30 The Dresden event also reveals the significant reduction in regulatory oversight that occurs after a reactor permanently shuts down. At the time of this event, the Dresden nuclear plant had two operating reactors and one permanently shut down reactor. Because of the operating reactors, the NRC had inspectors assigned full-time to the plant site supplemented by inspectors from its regional and headquarters offices. Clearly, those inspectors devoted almost all of their time and attention to the operating reactors; otherwise, they might have noticed that the owner turned off the Unit 1 spent fuel pool cooling and cleanup system 12 years earlier or had discontinued heating the Unit 1 reactor building 5 years earlier. Had Dresden Unit 1 not been adjacent to two operating reactors, the NRC would not have full-time inspectors assigned to the plant site.



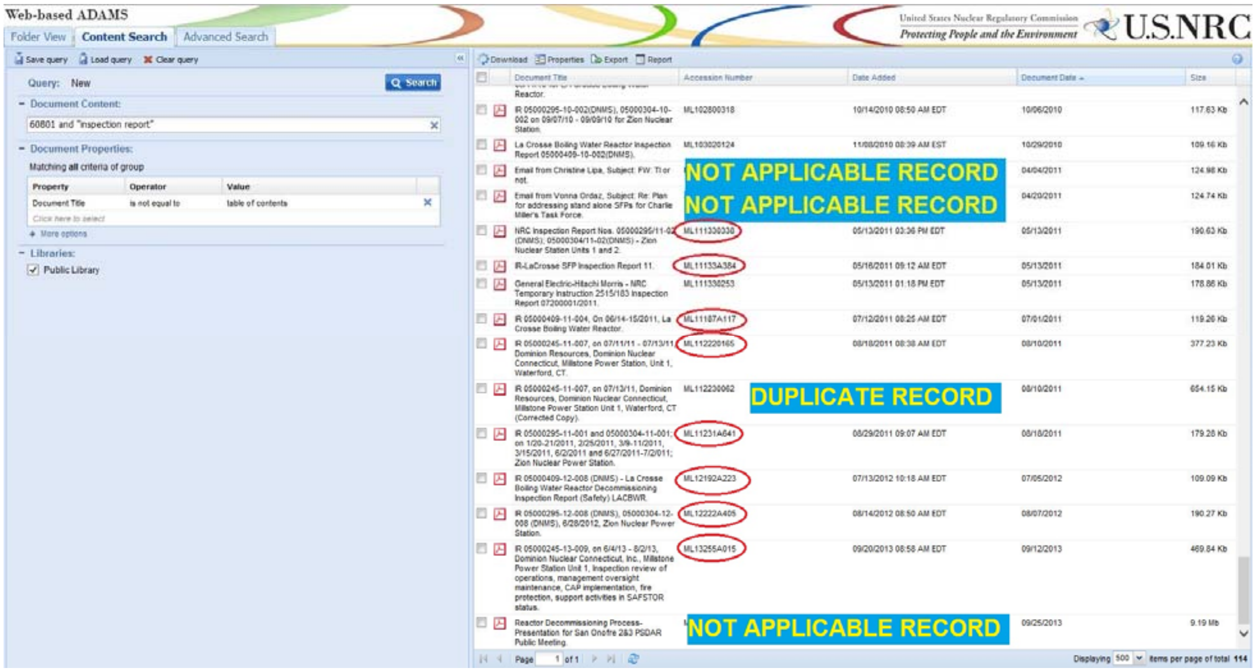
Source: NRC FOIA/PA-92-0537

7.31 The NRC inspection effort at Dresden is not unique. Shown above are the NRC inspection hours applied to various reactors in 1992. The Three Mile Island nuclear plant had one operating reactor and one permanently shut down reactor. Its Unit 1 reactor received nearly 3,700 inspection-hours of NRC attention while the permanently shut down Unit 2 reactor received about one-tenth of that attention, a scant 300 inspection-hours or so. In 1992, the Unit 1 reactor at the Browns Ferry nuclear plant had been shut down since March 1985 – not permanently shut down, but not expected to restart anytime soon (it did not resume operating until early 2007). NRC inspectors devoted less than 750 hours of attention to it during 1992. The permanently shut down Unit 1 reactor at Dresden was not even on the NRC's charts: the Dresden Units 2 and 3 reactors received over 3,000 NRC inspection-hours.

7.32 NRC Inspection Manual Chapter 0305, "Operating Reactor Assessment Program," is the agency's overall guidance document outlining the frequency and scope of the inspections it conducts at nuclear power reactors. On October 18, 2013, the NRC revised Manual Chapter 0305 to add this sentence:

> *A power reactor is no longer subject to this manual chapter after a licensee submits a written certification to cease operation in accordance with 10 CFR 50.82(a)(1)(ii).* (NRC 2013a)

7.33 NRC Inspection Manual Chapters 0350, "Oversight of Reactor Facilities in a Shutdown Condition Due to Significant Performance and/or Operational Concerns," and 0351, "Implementation of The Reactor Oversight Process at Reactor Facilities in an Extended Shutdown Condition for Reasons Other Than Significant Performance Problems," cover nuclear power reactors that have been shut down for lengthy periods, but which are expected to eventually resume operations. These manual chapters do not apply to permanently shut down reactors. A review of the Inspection Manual Chapters[13] and associated NRC Inspection Procedures[14] identified only one procedure applicable to permanently shut down nuclear power reactors (NRC 1997a). It focused on spent fuel pools. This sole procedure was developed in response to the 1994 event at Dresden Unit 1. According to the NRC, it is "estimated to require 32 onsite inspection hours semi-annually" (NRC 1997a).



Source: NRC ADAMS Website, accessed 11-04-2013

7.34 And it appears that the NRC's "semi-annual" spent fuel pool inspection expectations are actually being halfway met. According to the NRC's online electronic library, ADAMS, the NRC conducted this spent fuel pool inspection of the spent fuel pools at the permanently shut down Zion nuclear plant and documented its findings in reports dated May 13, 2011, August 18, 2011, and August 7, 2012 – three inspections over the past three years. And for the reasons described in Section VI of this declaration, even these infrequent NRC inspections provide little assurance that spent fuel pool leaks will be detected and corrected in a timely manner.

7.35 In summary, the NRC's WC DGEIS does not consider the reality that permanently shut down reactors receive less management attention (as evidenced by the Dresden Unit 1 event) and significantly less NRC oversight (as evidenced by the Dresden Unit 1 event and the inspection hour tabulation). This reality invalidates the NRC's assumptions that licensee programs and NRC's oversight will continue at the same levels after reactors shut down as existed when the reactors operated.

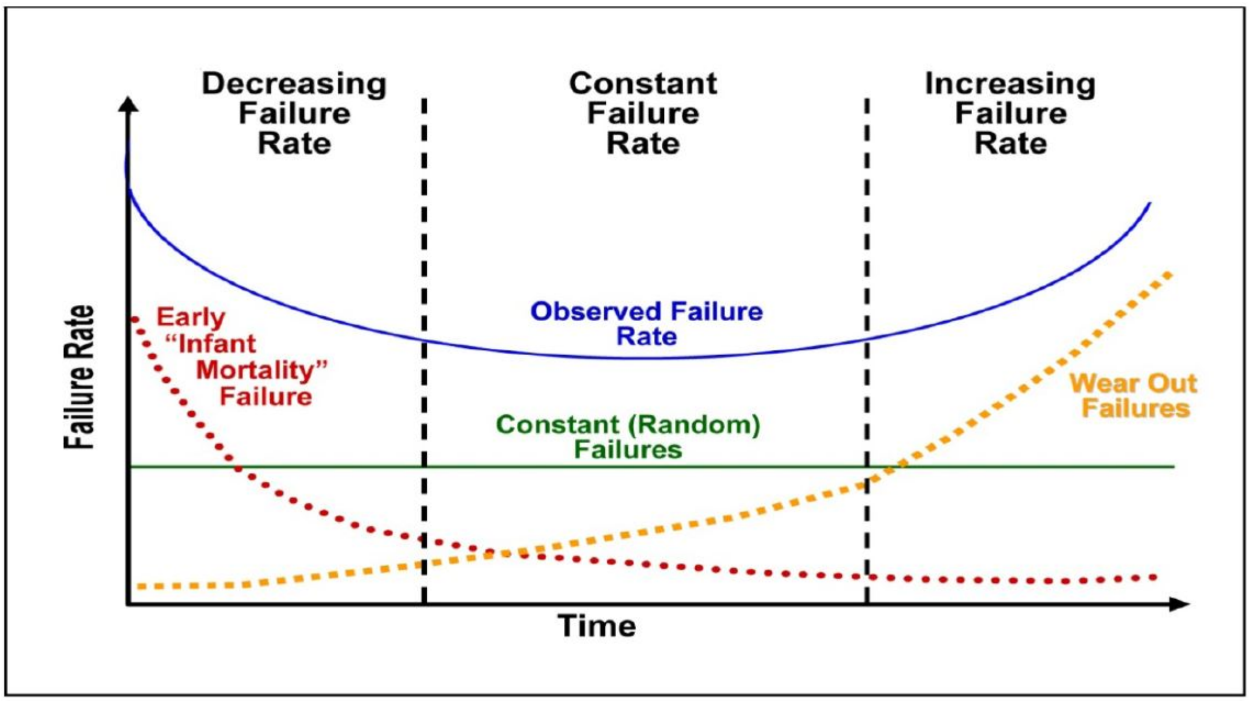
7.36 To meaningfully assess the impacts of spent fuel pool leaks in the WC DGEIS, the NRC must rely on regulatory requirements that will remain in place over the entire 60-year short-term

[13] See http://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/
[14] See http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/

storage period and not on regulatory requirements that are inapplicable or significantly reduced in scope after reactors permanently shut down. Only if the WC DGEIS achieves this can it provide reasonable assurance that spent fuel pool leaks will be detected before the leaked materials exceed public health regulatory limits and cause noticeable impacts to groundwater resources.

C. Reduction in Aging Management Protections

7.37 The WC DGEIS also fails to properly consider the significant reduction in scope for aging management regulatory requirements and associated supporting analyses that happens when nuclear power plants permanently shut down. Spent fuel pools and the piping and components connected to them are subject to aging degradation. Aging degradation does not magically cease when reactor operation ceases but continues on throughout the 60-year short-term storage phase. As depicted below in what is commonly called the "bathtub curve" due to its shape, aging degradation can cause the failure rate to increase:



Source: NRC 2013f

7.38 The NRC has approved renewed operating licenses for the majority of the nuclear power reactors operating today.[15] The NRC's license renewal rule (10 CFR. Part 54) enables the NRC to renew the original 40-year operating license for up to 20 additional years. The NRC will renew an operating license only after determining that the aging management program for in-scope passive systems, structures, and components is adequate:

[15] See "Completed Application" list at http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html

> *For each structure and component identified in paragraph (a)(1) of this section, demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB [current licensing basis] for the period of extended operation.* (10 CFR. §54.21(a)(3))

As described in Section A2 of the NRC's Generic Aging Lessons Learned Report (NRC 2012a), the spent fuel pool and associated equipment are within the scope of the license renewal rule and therefore require adequate aging management programs during the period of extended operation.

7.39 But the period of extended operation only covers the duration of reactor operation, not to the end of the 60-year short-term storage period as clearly illustrated in Figure 2.4 of the WC DGEIS:

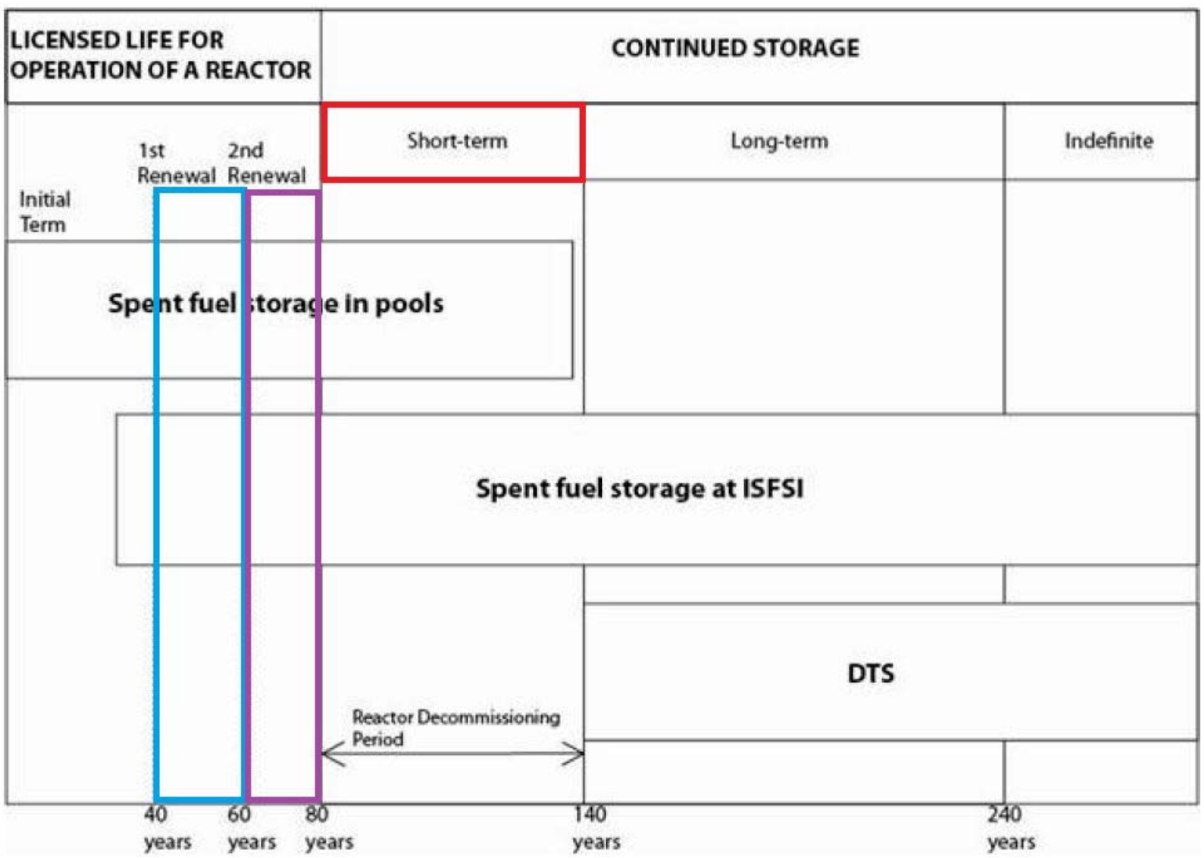


Figure 2-4. Continued Storage Timeline

7.40 The applicant for a renewed operating license develops aging management programs for in-scope systems, structures, and components—including the spent fuel pool and associated equipment—that provide reasonable assurance that required margins will be maintained over the duration of extended reactor operation. Once the period of extended operation ends and the short-term storage period begins, no regulations require licensees to continue their aging management programs.

7.41 The short-term storage period of 60 years equals the operating lifetime of a nuclear power reactor obtaining only one renewal – the 40-year initial term plus the 20-year period of extended operation. The aging management programs prepared by the applicants and approved by the NRC only consider the 20-year period of extended operation. While the efficacy of these programs does not automatically expire along with the operating licenses, the fact remains that neither the plant owners nor the NRC have formally evaluated aging degradation mechanisms and reliable barriers against excessive degradation over the 60-year short-term storage period assumed in the WC DGEIS.

7.42 The bathtub curve shows that aging degradation will eventually cause the failure rate to increase. Regulatory requirements such as the maintenance rule and the aging management programs mandated by the license renewal rule guard against problems caused by structures, systems, and components being operated deep into the Increasing Failure Rate portion on the right end of the bathtub curve. In other words, these mandated measures require that equipment affected by aging degradation be repaired or replaced before safety margins are compromised. The lack of comparable regulatory requirements during the 60-year short-term storage period increases the likelihood that unchecked aging degradation causes problems.

7.43 In summary, the WC DGEIS must consider the significant reduction in the scope of regulatory requirements and oversight that occurs after reactors permanently shut down rather than the inflated levels that exist while the reactors operate.

VIII. THE WC DGEIS FAILS TO CONSIDER SOME SIGNIFICANT IMPACTS FROM A SPENT FUEL POOL LEAK

8.1 The WC DGEIS is also inadequate because it fails altogether to consider a number of credible environmental impacts related to spent fuel pool leaks.

A. Offsite Contamination Below Standards and Onsite Contamination Excluded

8.2 The WC DGEIS fails to consider environmental impacts other than contamination in excess of NRC and EPA standards. (NRC 2013b, page E-18, lines 31-32). It also excludes onsite contamination. As a result, the WC DGEIS fails to consider numerous instances in which onsite contamination resulted in costly cleanups, which were required regardless of whether the licensee had failed to comply with NRC standards. In other words, compliance with NRC standards was insufficient protection against significant impacts.

8.3 For instance, the leak from the Salem spent fuel pool is not significant under the WC DGEIS criterion even though millions of dollars have been spent remediating tritium contamination in the groundwater. As described in Section IV.C above, water leaked from the spent fuel pool at the Salem nuclear plant prompted the State of New Jersey to compel its owner to remediate the site to recover the radioactively contaminated water. Over 28 million gallons of water have been drawn from the soil around the plant, treated, and either re-used by the plant or legally discharged (Arcadis 2013). Salem's leaking spent fuel pool did not result in any measured level of radioactivity in drinking water that exceeded federal standards, but it resulted in a sizeable cleanup cost. Spent fuel pool leaks in the future could pose financial burdens on stockholders, ratepayers, or taxpayers—a factor that NRC seems to have overlooked in the WC DGEIS.

8.4 Similarly, an onsite leak at the Oyster Creek nuclear plant in New Jersey costs millions of dollars to remediate. In April 2009, radioactively contaminated water leaked from an underground pipe at the Oyster Creek nuclear plant in New Jersey. The State of New Jersey ordered the plant's owner to clean up the leak. New Jersey Department of Environmental Protection Deputy Commissioner Iren Kropp was quoted as saying "They don't get a court hearing. They have to act and do exactly what we say" under the state's Spill Act. A company manager estimated the costs to exceed $13 million (Bates 2010). While this leak came from an underground pipe rather than the spent fuel pool, the contaminated water carried a hefty price tag even though it did not migrate offsite. The NRC fails to consider such onsite contamination consequences in the WC DGEIS.

8.5 And as discussed above in Section IV.D, Indian Point suffered a 50 gallon per day leak from the Unit 2 spent fuel pool that the owner believes to have lasted for over two years. This and other leaks discovered from the Unit 1 and Unit 2 spent fuel pools led to extensive and costly investigatory and assessment efforts at the site. Again, the WC DGEIS gives no indication that NRC considered such onsite contamination consequences.

8.6 While the source was an effluent pipe used to discharge radioactively contaminated water to the Kankakee River rather than the spent fuel pool, a leak discovered in 2005 at the Braidwood nuclear plant in Illinois had significant impact even though it did not result in any measured radionuclide concentrations in offsite groundwater used for drinking or in drinking wells in excess of EPA and NRC regulatory limits. Among the consequences from this leak:

- Exelon Corporation, Braidwood's owner, agreed to purchase one property and reimburse 14 other property owners for devaluations stemming from the leak (Dow Jones, 2005).
- The NRC's Chairman described the leak in his four-page transmittal letter for a monthly report to Congressional oversight committee Chairs and Ranking Members (NRC 2006c, page 2). Thus, leakage resulting in no offsite contamination above regulatory limits—considered insignificant in the WC DGEIS—was considered significant enough to promptly report it to the U.S. Congress.
- The Illinois Attorney General and the Will County State's Attorney jointly filed a lawsuit against Exelon on eight counts related to the leaks (Illinois Attorney General, 2006).
- Exelon agreed to provide bottled water to about 420 homeowners near the Braidwood nuclear plant (Associated Press, 2006).
- Exelon, the Illinois Attorney General, and the Will County State's Attorney settled the leak lawsuit on May 11, 2006. Per the agreement, Exelon agreed to reimburse the State of Illinois and Will County for all their costs related to the leak, to implement several remediation measures, and to take other measures intended to prevent future leaks (Twelfth Circuit Court, 2006).

8.7 In summary, the Salem, Oyster Creek and Indian Point cases clearly demonstrated that leaks contaminating the plant's property can have significant impacts. And the Braidwood case clearly demonstrates that leaks contaminated offsite properties below regulatory limits can also have significant impacts. The WC DGEIS cannot summarily dismiss this reality.

B. Social and Economic Impacts

8.8 The WC DGEIS does not properly consider the social and economic effects of contamination in nearby communities. These effects can be significant.

8.9 For example, during a workshop on groundwater protection conducted by the NRC on April 20, 2010, Bill Buscher of the State of Illinois Environmental Protection Agency pointed out that the millions of gallons of radioactively contaminated water that leaked from the Braidwood nuclear plant and migrated offsite and into people's drinking wells had serious implications even though the measured tritium concentrations were within the federal standards for drinking water. Buscher explained that several nearby residents were approaching retirement age and had planned to sell their properties and use the proceeds to relocate to live out their golden years. But the specter of radioactive contamination sent real estate prices spiraling downward. It is not clear from the WC DGEIS that the NRC considers potential property devaluations caused by spent fuel pool leaks.

C. Licensee Longevity

8.10 The WC DGEIS assumes that companies owning permanently shut down reactors are immortal. As of 2003, the companies comprising the Standard & Poor 500 stock index (S&P 500) had been publicly traded for an average of 25 years, with this average trending towards shorter values.[16] The NRC assumes in the WC DGEIS that spent fuel pools could be around for up to 140 years (40 year original operating license period along with two 20-year license extensions followed by up to 60 years of short-term storage after reactor operation permanently ceases). The NRC thus assumes that the owner, or licensee, responsible for maintaining the spent fuel pool and monitoring against leaks will endure for 5.6 times longer than the average lifetime of the S&P 500 companies. The NRC apparently failed to consider, from a socioeconomic perspective, the fact that an owner no longer receiving revenue from a permanently retired generating plant may not survive for six decades. The WC DGEIS needs to either explain how bankruptcy, changes in ownership, takeover by the state, and other ownership issues cannot occur during the 60-year short-term storage period or explain how the spent fuel pool leak risk will be properly managed during and following such ownership issues.

[16] Per August 25, 2010, posting to http://www.investopedia.com/stock-analysis/2010/the-average-lifespan-of-sp-500-companies-xom-aapl-pg-ibm-jnj0825.aspx

IX. Conclusions

9.1 The WC DGEIS concedes that long-term, low-volume spent fuel pool leaks could exceed public health regulatory limits and impact groundwater resources. Although the WC DGEIS concludes that any such leaks are very unlikely to happen, it fails to provide solid, reliable support for this conclusion.

9.2 The WC DGEIS does not show that the NRC has considered all relevant spent fuel pool leaks. For instance, the NRC did not consider the leaks that occurred from the spent fuel pools at the Brookhaven National Laboratory and the Yankee Rowe nuclear plant. The BNL spent fuel pool leaked radioactively contaminated water into the ground for up to 12 years. Four tests for leakage from the spent fuel pool over a seven year period failed to detect the leak. And numerous monitoring wells already existing or added to the site failed to detect the leaked water for many years or attributed leak indications other sources. But this event was not included among the past events NRC considered for the WC DGEIS. Likewise, the NRC failed to consider in the WC DGEIS the two million gallons that leaked from the Yankee Rowe nuclear plant.

9.3 In the WC DGEIS, NRC assumes that spent fuel pool leaks of 100 gallons per day or more would be readily detected before causing significant impacts. In making this assumption, the NRC relies on the availability of spent fuel pool leakage detection system and groundwater monitoring measures. But the WC DGEIS fails to properly consider that spent fuel pool water level instrumentation is not required to be functioning except during the very rare occasions when irradiated fuel is being moved within the pool and that groundwater monitoring measures are entirely voluntary. Thus, the NRC relies on measures that quite simply may be non-existent. In addition, the WC DGEIS fails to explain how leakage far in excess of 100 gallons remained undetected at Yankee Rowe until two million gallons of radioactively contaminated water had escaped into the soil.

9.4 In the WC DGEIS, the NRC fails to justify its conclusion that spent fuel pool leaks of less than 100 gallons per day either will be detected in a timely manner or will cause no significant impact if undetected for an extended period. The BNL and Indian Point leaks contradict the NRC's conclusion because each involved releases of tens of thousands of gallons, but at rates of less than 50 gallons per day. The WC DGEIS dismisses leaks smaller than 100 gallons per day, regardless of their duration, but without explicitly defining the hazard and protections credited against it (as discussed in paragraphs 6.31 to 6.37), this dismissal is speculative and subjective.

9.5 In the WC DGEIS, the NRC fails to identify how the spent fuel pool leaks listed in Table E-4 were detected. By not identifying the means of detecting these past leaks, the WC DGEIS fails support its assumption that leaks will be readily detectable. Instead, the WC DGEIS leaves open the possibility that the leaks were only detected through sheer luck. The WC DGEIS must explicitly identify the means by which past leaks were detected and ensure that regulatory requirements will retain these means throughout the 60-year short-term storage period. Otherwise, the NRC has no basis for a finding of reasonable assurance that the methods on which it relies will detect future leaks.

9.6 In the WC DGEIS, the NRC fails to recognize that both regulatory requirements and its oversight regime are significantly scaled back when nuclear power reactors cease operation. For example, the aging management measures supporting renewal of reactor operating licenses only apply during the period of extended reactor operation—not the six decades of spent fuel pool storage that follow. And evidence shows that the NRC's inspection effort is drastically reduced, to almost drive-by inspection efforts, after a reactor permanently shuts down.

9.7 For the WC DGEIS, the NRC fails to properly consider impacts from leaks causing offsite contamination below federal health standards and onsite contamination. The Braidwood event, for example, reveals that leaks resulting in offsite contamination cause significant impacts while the Salem and Oyster Creek events reveal that leaks resulting in onsite contamination can also entail significant impacts.

9.8 The NRC lacks the regulatory backstop needed to validate assumptions made for the WC DGEIS about spent fuel pool leakage detection capabilities and leak impacts. Consequently, the conclusion in the WC DGEIS that spent fuel pool leaks cannot have significant impacts may not be relied upon.

9.9 The WC DGEIS must be revised to explicitly and properly:

- Identify the regulatory requirements in place throughout the short-term storage period that provide reasonable assurance that spent fuel pool leakage of X[17] gallons per day or greater will be detected before causing significant impacts.

- Demonstrate by analysis applicable to all sites, or require site-specific analyses, showing that spent fuel pool leakage of less than X gallons per day of infinite duration cannot cause significant impacts.

9.10 Absent the failures and deficiencies identified in this declaration being adequately remedied, the WC DGEIS cannot support rulemaking and policies allowing irradiated fuel to be stored in spent fuel pools for up to 60 years following cessation of reactor operation. Past spent fuel pool leaks raise serious questions about safety and environmental risks from future leaks. Those questions must have sound and well-supported answers before the NRC approves the storage of spent fuel in pools for 60 years following reactor operation. Otherwise, post-operational spent fuel storage is nothing more than a six-decade gamble.

I declare that the foregoing facts are true to the best of my knowledge and that the opinions expressed above are based on my best professional judgment.

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Date: 12/13/2013

[17] In the WC DGEIS, the NRC assumed an X value of 100. Correcting the many deficiencies, errors, and shortcomings identified by this declaration may result in a final X value higher or lower than 100.

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Appendix A

Source: NRC 2011b

Table 1

Number of Program Elements Rated Incomplete in Region 1 (for 2008-2010)

The 11 Objectives in NEI 07-07 are listed at the right.	Readiness Potential (2008-2010)*	Hydrology and Geology	Site Risk Assessment	On-Site Groundwater Monitoring	Remediation Process	Record Keeping	Stakeholder Briefings	Voluntary Communications	30-Day Reports	Annual Reports	Self Assessments	NEI Program Assessments
Region 1		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	3.1	3.2
Beaver Valley	1											
Calvert Cliffs	1											
FitzPatrick	3		4	4	3							
Ginna	2	3	3	2								
Hope Creek	1											
Indian Point	1											
Limerick	1											
Millstone	1											
Nine Mile Point	1											1
Oyster Creek	2		1	1	3						1	1
Peach Bottom	1		2	2								1
Pilgrim	1											
Salem	1											
Seabrook	1											
Susquehanna	1											
Three Mile Island	2		1	1	2	1						1
Vermont Yankee	3	3	6	1						1	3	1

* Sites with a readiness potential of "1" should have the highest potential to effectively manage

Haddam Neck, Maine Yankee, Saxton and Yankee-Rowe are sites with permanently shut down nuclear power reactors that did not receive a TI-2515/173 inspection between 2008 and 2010.

Table 2

Number of Program Elements Rated Incomplete in Region 2 (for 2008-2010)

The 11 Objectives in NEI 07-07 are listed at the right.	Readiness Potential (2008-2010)*	Hydrology and Geology	Site Risk Assessment	On-Site Groundwater Monitoring	Remediation Process	Record Keeping	Stakeholder Briefings	Voluntary Communications	30-Day Reports	Annual Reports	Self Assessments	NEI Program Assessments
Region 2		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	3.1	3.2
Browns Ferry	1											
Brunswick	1											
Catawba	1											
Crystal River	1											
Farley	1						3					
Harris	1											
Hatch	1		1									
McGuire	1											
North Anna	1											
Oconee	1											
Robinson	1											
Saint Lucie	1											
Sequoyah	1											
Summer	1											
Surry	1											
Turkey Point	1											
Vogtle	1											
Watts Bar	1							1				

Appendix A

Table 3

Number of Program Elements Rated Incomplete in Region 3 (for 2008-2010)

The 11 Objectives in NEI 07-07 are listed at the right.	Readiness Potential (2008-2010)*	Hydrology and Geology	Site Risk Assessment	On-Site Groundwater Monitoring	Remediation Process	Record Keeping	Stakeholder Briefings	Voluntary Communications	30-Day Reports	Annual Reports	Self Assessments	NEI Program Assessments
Region 3		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	3.1	3.2
Braidwood	1											
Byron	1				2		1					
Clinton	1											
D.C. Cook	1											
Davis-Besse	1				1							1
Dresden	1			3	1							
Duane Arnold	1											
Fermi	1											
Kewaunee	2		2		2	1	3					
La Salle	1		1									
Monticello	1						2					
Palisades	1		3		1							
Perry	2	1	1	1	1			3				
Point Beach	1											
Prairie Island	1											
Quad Cities	1			2								

Big Rock Point, Elk River, Fort St. Vrain, Hallam, La Crosse, Zion[18] are sites with permanently shut down nuclear power reactors that did not receive a TI-2515/173 inspection between 2008 and 2010.

[18] As of March 29, 2012, Zion still stored irradiated fuel in its spent fuel pool per NRC webpage http://www.nrc.gov/info-finder/decommissioning/power-reactor/zion-nuclear-power-station-units-1-2.html

Appendix A

Table 4

Number of Program Elements Rated Incomplete in Region 4 (for 2008-2010)

The 11 Objectives in NEI 07-07 are listed at the right.	Readiness Potential (2008-2010)*	Hydrology and Geology	Site Risk Assessment	On-Site Groundwater Monitoring	Remediation Process	Record Keeping	Stakeholder Briefings	Voluntary Communications	30-Day Reports	Annual Reports	Self Assessments	NEI Program Assessments
Region 4		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	3.1	3.2
Arkansas Nuclear	3		5	1				1		2		
Callaway	3		4	3	3							
Columbia	2		5									
Comanche Peak	1											
Cooper	3	4	7		3					2		
Diablo Canyon	3		7		3			4			1	
Fort Calhoun	1											
Grand Gulf	1											
Palo Verde	1							4				
River Bend	3	2	6	3	1					1	1	
San Onofre	1											
South Texas	1											
Waterford	3	2	6	3	1						1	
Wolf Creek	1											

Humboldt Bay, Rancho Seco, Trojan are sites with permanently shut down nuclear power reactors that did not receive a TI-2515/173 inspection between 2008 and 2010.

Appendix B

BASELINE INSPECTION PROCEDURES

IP/IA No.	Title	Frequency[1]
71111 Reactor Safety – Initiating Events, Mitigating Systems, Barrier Integrity		
71111.01	Adverse Weather Protection	A
	(Reserved)	
	(Reserved)	
71111.04	Equipment Alignment	Q/A
71111.05AQ	Fire Protection Annual/Quarterly	Q/A
71111.05T	Fire Protection (Triennial)	T
71111.05TTP	Fire Protection – NFPA 805 (Triennial)	T
71111.06	Flood Protection Measures	A
71111.07	Heat Sink Performance	A/T
71111.08	Inservice Inspection Activities	R
	(Reserved)	
	(Reserved)	
71111.11	Licensed Operator Requalification Program and Licensed Operator Performance	Q/B
71111.12	Maintenance Effectiveness	A
71111.13	Maintenance Risk Assessment and Emergent Work Control	A
	(Reserved)	
71111.15	Operability Determinations and Functionality Assessments	A
	(Reserved)	
71111.17	Evaluations of Changes, Tests, or Experiments and Permanent Plant Modifications	T
71111.18	Plant Modifications	A
71111.19	Post –Maintenance Testing	A
71111.20	Refueling and Other Outage Activities	R
71111.21	Component Design Bases Inspection	T
71111.22	Surveillance Testing	A
	(Reserved)	
71114 Reactor Safety – Emergency Preparedness		
71114.01	Exercise Evaluation	B
71114.02	Alert Notification System Testing	B

Issue Date: 03/08/13 Att 3-1 2515 Appendix A

Source: NRC 2013e

Appendix C

NRC Inspection Findings at Operating Nuclear Power Plants as posted August 28, 2013, at http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/pim_summary.html
NRC findings in order of increasing safety significance: Green, White, Yellow, Red
(Security-related White, Yellow, and Red are shown as blue Greater-than-Green (GTG))

2Q/2013 ROP Inspection Findings Summary

This summary provides the color designation of the most significant inspection findings over the previous 4 quarters.

The Commission has decided that certain information about findings pertaining to security cornerstone will not be publicly available to ensure that potentially useful information is not provided to a possible adversary; while other information will be available. Therefore, the cover letters to security inspection reports may be viewed.

Plants	Initiating Events	Mitigating Systems	Barrier Integrity	Emergency Preparedness	Occupational Radiation Safety	Public Radiation Safety	Security
Arkansas Nuclear 1	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Arkansas Nuclear 2	Green	Green	Green	No Finding	Green	No Finding	No Finding
Beaver Valley 1	No Finding	Green	No Finding	No Finding	No Finding	No Finding	GTG
Beaver Valley 2	Green	Green	No Finding	No Finding	No Finding	No Finding	GTG
Braidwood 1	No Finding	Green	Green	No Finding	No Finding	No Finding	Green
Braidwood 2	No Finding	Green	Green	No Finding	No Finding	No Finding	Green
Browns Ferry 1	No Finding	Red (1)	No Finding	Green	No Finding	No Finding	Green
Browns Ferry 2	No Finding	Green	No Finding	Green	No Finding	No Finding	Green
Browns Ferry 3	Green	Green	No Finding	Green	No Finding	No Finding	Green
Brunswick 1	Green	Green	Green	Green	No Finding	No Finding	No Finding
Brunswick 2	Green	Green	Green	Green	No Finding	No Finding	No Finding
Byron 1	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Byron 2	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Callaway	Green	Green	Green	No Finding	Green	No Finding	Green
Calvert Cliffs 1	Green	Green	Green	No Finding	No Finding	No Finding	Green
Calvert Cliffs 2	No Finding	Green	Green	No Finding	No Finding	No Finding	Green
Catawba 1	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Catawba 2	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Clinton	Green	Green	Green	No Finding	Green	No Finding	No Finding
Columbia Generating Station	Green	Green	Green	White (2)	Green	No Finding	Green
Comanche Peak 1	Green	Green	Green	No Finding	No Finding	No Finding	Green
Comanche Peak 2	Green	Green	Green	No Finding	No Finding	No Finding	Green
Cooper	Green	Green	No Finding	Green	Green	No Finding	No Finding
Crystal River 3	No Finding	No Finding	No Finding	No Finding	No Finding	No Finding	No Finding

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D.C. Cook 1	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
D.C. Cook 2	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Davis-Besse	Green	Green	Green	No Finding	No Finding	No Finding	GTG
Diablo Canyon 1	Green	Green	Green	No Finding	No Finding	No Finding	Green
Diablo Canyon 2	Green	Green	Green	No Finding	No Finding	No Finding	Green
Dresden 2	No Finding	White (1)	No Finding	No Finding	No Finding	No Finding	No Finding
Dresden 3	No Finding	White (1)	No Finding	No Finding	No Finding	No Finding	No Finding
Duane Arnold	Green	Green	Green	No Finding	Green	Green	No Finding
Farley 1	Green	Green	No Finding	No Finding	Green	No Finding	Green
Farley 2	Green	Green	No Finding	No Finding	Green	No Finding	Green
Fermi 2	Green	Green	No Finding	No Finding	No Finding	No Finding	Green
FitzPatrick	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Fort Calhoun	Red (1)	Yellow (1)	Green	Green	Green	Green	GTG
Ginna	Green	Green	Green	No Finding	No Finding	No Finding	Green
Grand Gulf 1	Green	Green	Green	No Finding	Green	No Finding	Green
Harris 1	Green	Green	No Finding	No Finding	No Finding	No Finding	Green
Hatch 1	Green	Green	Green	Green	No Finding	No Finding	No Finding
Hatch 2	Green	Green	Green	Green	No Finding	No Finding	No Finding
Hope Creek 1	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Indian Point 2	Green	Green	No Finding	No Finding	No Finding	No Finding	Green
Indian Point 3	No Finding	Green	No Finding	No Finding	No Finding	No Finding	Green
La Salle 1	Green	Green	No Finding	No Finding	Green	No Finding	No Finding
La Salle 2	Green	Green	No Finding	No Finding	Green	No Finding	No Finding
Limerick 1	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Limerick 2	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
McGuire 1	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
McGuire 2	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Millstone 2	No Finding	Green	No Finding	Green	No Finding	No Finding	Green
Millstone 3	Green	Green	Green	Green	No Finding	No Finding	Green
Monticello	Green	Green	No Finding	No Finding	No Finding	Green	Green
Nine Mile Point 1	Green	No Finding	Green	No Finding	No Finding	No Finding	Green
Nine Mile Point 2	Green	Green	No Finding	No Finding	Green	Green	Green

Appendix C

NRC Inspection Findings at Operating Nuclear Power Plants as posted August 28, 2013, at
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NRC findings in order of increasing safety significance: Green, White, Yellow, Red
(Security-related White, Yellow, and Red are shown as blue Greater-than-Green (GTG))

North Anna 1	No Finding	Green	No Finding	Green	No Finding	No Finding	No Finding
North Anna 2	Green	Green	No Finding	Green	No Finding	No Finding	No Finding
Oyster Creek	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Oconee 1	No Finding	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Oconee 2	No Finding	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Oconee 3	No Finding	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Palisades	Green	Green	No Finding	No Finding	Green	No Finding	Green
Palo Verde 1	No Finding	Green	Green	Green	No Finding	No Finding	Green
Palo Verde 2	Green	Green	Green	Green	No Finding	No Finding	Green
Palo Verde 3	No Finding	Green	Green	Green	No Finding	No Finding	Green
Peach Bottom 2	No Finding	Green	Green	No Finding	No Finding	No Finding	Green
Peach Bottom 3	No Finding	No Finding	No Finding	No Finding	No Finding	No Finding	Green
Perry 1	Green	Green	Green	Green	White (2)	No Finding	Green
Pilgrim 1	Green	Green	No Finding	No Finding	No Finding	No Finding	Green
Point Beach 1	Green	White (2)	Green	No Finding	Green	No Finding	No Finding
Point Beach 2	Green	White (1)	Green	No Finding	Green	No Finding	No Finding
Prairie Island 1	Green	Green	No Finding	White (1)	No Finding	No Finding	Green
Prairie Island 2	Green	Green	Green	No Finding	No Finding	No Finding	Green
Quad Cities 1	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
Quad Cities 2	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
River Bend 1	Green	Green	Green	No Finding	Green	No Finding	Green
Robinson 2	No Finding	Green	Green	No Finding	No Finding	No Finding	No Finding
Saint Lucie 1	Green	Green	No Finding	No Finding	No Finding	Green	Green
Saint Lucie 2	No Finding	Green	No Finding	No Finding	No Finding	Green	Green
Salem 1	Green	Green	Green	No Finding	No Finding	No Finding	No Finding
Salem 2	Green	Green	No Finding	No Finding	No Finding	No Finding	No Finding
San Onofre 2	Green	Green	No Finding	Green	No Finding	Green	Green
San Onofre 3	Green	Green	No Finding	Green	No Finding	Green	Green
Seabrook 1	Green	Green	No Finding	Green	Green	No Finding	No Finding
Sequoyah 1	No Finding	White (1)	No Finding	No Finding	No Finding	No Finding	No Finding
Sequoyah 2	Green	White (1)	Green	No Finding	No Finding	No Finding	No Finding

Appendix D

Curriculum vitae of David A. Lochbaum
PO Box 15316
Chattanooga, TN 37415
(423) 468-9272, office
(423) 488-8318, cell

EDUCATION

June 1979 Bachelor of Science in Nuclear Engineering, The University of Tennessee at Knoxville

EXPERIENCE SUMMARY

03/10 to date *Director – Nuclear Safety Project*
Union of Concerned Scientists

Responsible for directing UCS's nuclear safety program, for monitoring developments in the nuclear industry, for serving as the organization's spokesperson on nuclear safety issues, for initiating action to correct safety concerns, for authoring reports and briefs on safety issues, and for presenting findings to the Nuclear Regulatory Commission, the US Congress, and state and local officials.

03/09 to 03/10 *Reactor Technology Instructor*
U.S. Nuclear Regulatory Commission
Technical Training Center

Responsible for providing initial qualification and re-qualification training on boiling water reactor technology for NRC employees. Activities included revising chapters of the training manual, conducting classroom and control room simulator training sessions, maintaining the test question database, administering examinations, and assisting the development of an interactive 3-D model of the reactor pressure vessel and its internals.

10/96 to 02/09 *Director - Nuclear Safety Project*
Union of Concerned Scientists

Responsible for directing UCS's nuclear safety program, for monitoring developments in the nuclear industry, for serving as the organization's spokesperson on nuclear safety issues, for initiating action to correct safety concerns, for authoring reports and briefs on safety issues, and for presenting findings to the Nuclear Regulatory Commission, the US Congress, and state and local officials.

11/87 to 09/96 *Senior Consultant*
Enercon Services, Inc.

Responsible for developing the conceptual design package for the alternate decay heat removal system, for closing out partially implemented modifications, reducing the backlog of engineering items, and providing training on design and licensing bases issues at the Perry Nuclear Power Plant.

Responsible for developing a topical report on the station blackout licensing bases for the Connecticut Yankee plant.

Responsible for vertical slice assessment of the spent fuel pit cooling system and for confirmation of licensing commitment implementation at the Salem Generating Station.

Responsible for developing the primary containment isolation devices design basis document, reviewing the emergency diesel generators design basis document, resolving design document open items, and updating design basis documents for the FitzPatrick Nuclear Power Plant.

Responsible for the design review of balance of plant systems and generating engineering calculations to support the Power Uprate Program for the Susquehanna Steam Electric Station.

Responsible for developing the reactor engineer training program, revising reactor engineering technical and surveillance procedures and providing power maneuvering recommendations at the Hope Creek Generating Station.

Responsible for supporting the lead BWR/6 Technical Specification Improvement Program and preparing licensing submittals for the Grand Gulf Nuclear Station.

03/87 to 08/87 *System Engineer*
General Technical Services

Responsible for reviewing the design of the condensate, feedwater and raw service systems for safe shutdown and restart capabilities at the Browns Ferry Nuclear Plant.

08/83 to 02/87 *Senior Engineer*
Enercon Services, Inc.

Responsible for performing startup and surveillance testing, developing core monitoring software, developing the reactor engineer training program, and supervising the reactor engineers and Shift Technical Advisors at the Grand Gulf Nuclear Station.

10/81 to 08/83 *Reactor Engineer / Shift Technical Advisor*
Tennessee Valley Authority
Browns Ferry Nuclear Plant

Responsible for performing core management functions, administering the nuclear engineer training program, maintaining ASME Section XI program for the core spray and control rod drive systems, and covering STA shifts at the Browns Ferry Nuclear Plant.

06/81 to 10/81 *BWR Instructor*
General Electric Company
BWR/6 Training Center

Responsible for developing administrative procedures for the Independent Safety Engineering Group (ISEG) at the Grand Gulf Nuclear Station.

01/80 to 06/81 *Reactor Engineer / Shift Technical Advisor*
Tennessee Valley Authority
Browns Ferry Nuclear Plant

Responsible for directing refueling floor activities, performing core management functions, maintaining ASME Section XI program for the RHR system, providing power maneuvering recommendations and covering STA shifts at the Browns Ferry Nuclear Plant.

06/79 to 12/79 *Junior Engineer*
Georgia Power Company
Edwin I. Hatch Nuclear Plant

Responsible for completing pre-operational testing of the radwaste solidification systems and developing design change packages for modifications to the liquid radwaste systems at the Edwin I. Hatch Nuclear Plant. Also qualified as a station nuclear engineer and covered shifts during startups, control rod pattern exchanges, and other power maneuvers.

OTHER QUALIFICATIONS

January 2010 Certified as a boiling water reactor technology instructor at the U.S. Nuclear Regulatory Commission

April 1982 Certified as a Shift Technical Advisor at the TVA Browns Ferry Nuclear Plant

May 1980 Certified as an Interim Shift Technical Advisor at the TVA Browns Ferry Nuclear Plant

Member, American Nuclear Society (since 1978).