From: Brian Magnuson <magnuson28@msn.com>
Sent: Tuesday, May 02, 2023 10:44 PM
To: Kevin Folk; Jennifer Davis
Cc: Karen Gray; Jack Kolar; Gabrielle DeStefano; Brian Magnuson
Subject: [External_Sender] RE: Docket ID NRC-2018-0296 – Draft NUREG-1437 Revision 2 - Magnuson Public Comments

RE: Docket ID NRC-2018-0296 – Draft NUREG-1437 Revision 2

Comments by Brian Magnuson
Lead Emergency Management Specialist at Constellation Energy Corporation
Former Reactor Operator, Senior Reactor Operator and, Operations Shift Manager at Quad Cities Nuclear Power Plant
—I submit these comments as a member of the public.

May 1, 2023

Dear NRC Staff:

Like others, I respectfully request that the Nuclear Regulatory Commission (NRC) extend the deadline for public comment on the *Comment Period of Renewing Nuclear Power Plant Operating Licenses—Environmental Review*, 88 Fed. Reg. 13,329 (March 3, 2023), for an additional sixty (60) days.

I am opposed to the proposed rule package that reclassifies the current Category 2, Severe Accidents, as a Category 1—Generic Issue. I am also opposed to classifying Spent Fuel Accidents as a Category 1—Generic Issue.

My review of Draft NUREG-1437 Revision 2 is limited to Section E.3.7 '*Impact From Accidents at Spent Fuel Pools*.'

I found the referenced studies of Section E.3.7 do not support its casual assumptions and conclusions.

For example, Section E.3.7 misapplies NUREG-1738, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," to the risk of operating nuclear power plants (that may request License Renewal). The risks and consequences at decommissioned nuclear plants are lower than operating plants. The SFP at decommissioned nuclear plants contain no 'hot' fuel bundles and their reactors are defueled. Accordingly, there is no risk of a severe SFP accident causing a concurrent reactor accident at a decommissioned nuclear plant.

Other inconsistencies include:

1. The accidents at Fukushima demonstrated that multiple concurrent reactor-SFP accidents are credible. Despite this demonstration and contrary to Fukushima Near Term Task Force recommendations (SECY-11-093), the NRC has not yet evaluated the consequences of multiple concurrent reactor-SFP accidents—which would have the most impact on the environment.

2. NRC studies that assess the radiological consequences of SFP accidents, such as NUREG-1738 and SMSAB-99-02, project off-site "early fatalities" or "prompt fatalities" out to 100 miles. Despite the potentially deadly off-site consequences of a SFP accident, the NRC has failed to adequately assess the on-site (ground zero) consequences which would obviously be much worse. The on-site

radiological consequences could prevent mitigative actions and lead to multiple concurrent reactor-SFP accidents.

3. Contrary to the regulations listed in Regulatory Guide 1.29, '*Seismic Design Classification,'* some existing SFP structures and SFP gates are not designed to withstand the effects of the design-basis earthquake (Safe Shutdown Earthquake), much less a beyond-design-basis earthquake. Instead of identifying and addressing the vulnerabilities created by these design deficiencies (as recommended by the Fukushima NTTF), the NRC simply proffers that (Non-Seismic Category I) SFP structures and gates are "robust" and are not expected to fail in beyond-design-basis seismic events.

These inconsistencies, and others identified in my comments, indicate that some scientific integrity has been lost in Draft NUREG-1437 Revision 2 and in referenced research products. The losses of scientific integrity also appear to circumvent Public Law 112-074 and may constitute research misconduct.

Protecting the Integrity of Government Science (January 2022):

> *The American public has the right to expect from its government accurate information, data, and evidence and scientifically-informed policies, practices, and communications. This requires scientific integrity—based on rigorous scientific research that is free from politically motivated suppression or distortion. Violations of scientific integrity damage trust in both science and government. These lapses are contrary to the core ideals of the U.S. scientific enterprise, including openness, transparency, honesty, equity, and objectivity. They also erode the morale and innovation of Federal scientists and technologists.*
>
> *Protecting scientific integrity in government is vital to the Nation. The convergence of economic, public health, social justice, biodiversity, and climate crises facing the Nation underscores the need for evidence-based decisions guided by the best available science.1 Scientific integrity aims to make sure that science is conducted, managed, communicated, and used in ways that preserve its accuracy and objectivity and protect it from suppression, manipulation, and inappropriate influence—including political interference. It is a central issue not only for Federal departments and agencies (referred to collectively as "agencies" in this report) that conduct and fund scientific research, 2 but also for all agencies that communicate or make use of scientific and technical information in decision-making and for members of the American public who are affected by government decisions.*

Please consider my comments in the tables below.

Sincerely,
Brian Magnuson
magnuson28@msn.com

Draft NUREG-1437 Revision 2 E.3.7 Impact From Accidents at Spent Fuel Pools	**Comments**
The 1996 LR GEIS did not include an explicit assessment of the environmental impacts of accidents at the SFPs located at each reactor site. The 1996 LR GEIS did, however, <u>discuss qualitatively</u> (see Section 5.2.3.1) the reasons why the impact of accidents at SFPs would be much less than that from reactor accidents. Thus, in Table B-1 of 10 CFR Part 51, it was concluded that accidents at SFPs could be classified as Category 1 and not require further analysis in support of license renewal.	Contrary to Draft NUREG-1437 Revision 2, the NRC knows that the environmental impacts of SFP could be greater than reactor accidents. NUREG-2161 explains why the radiological consequences of a

<u>This was primarily because of the resolution of Generic Safety Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools," concluded that the risk from accidents at SFPs was low</u> and, accordingly, no additional regulatory action was necessary. The analysis supporting this conclusion is contained in NUREG-1353 (NRC 1989c).	severe SFP accident could be greater than that of a reactor core melt accident. "*This is because a spent fuel pool stores significantly more fuel assemblies than a reactor core. Additionally, radionuclides released during a spent fuel pool accident have longer half-lives (e.g., Cesium-137) than those that would be released during a reactor accident.*" Furthermore, the NRC has not evaluated the integrated environmental impacts of multi-reactor/SFP accidents as recommended by the Fukushima NTTF. Reference NUREG-2161 Table 35, Average Land Interdiction and Table 33, *Overall Consequence Results*, which lists the radiological and environmental consequences of a single SFP accident. Given these NRC references, it seems wrong to classify SFP accidents as Category 1. The Fukushima Near Term Task Force (NTTF) recommendations, and NRC Orders EA-12-051 and EA-12-049, expose the fact that NUREG-1353 did not resolve the Generic Safety Issue of "Beyond Design Basis Accidents in Spent Fuel Pools." It is unacceptable to base pending or future LR GEIS regulatory conclusions or decisions on Generic Safety Issue 82 and NUREG-1353. The 1996 LR GEIS information is stale. It does not reflect the current state of knowledge or the lessons learned from Fukushima. It is unacceptable to base pending or future LR GEIS regulatory conclusions or decisions on the 1996 LR GEIS. This information is new and significant.

	Until the NRC takes a 'hard look' at the environmental impacts of integrated plant-specific multi-reactor/SFP accidents—that include on-site dose consequences, it seems imprudent to consider any license renewals. Again, I believe it is unacceptable to classify SFP accidents as Category 1.
References	**Reference Comments**
Generic Safety Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools": *The staff concluded that reducing the risk from spent fuel pools due to events beyond the SSE would still leave a comparable risk due to core damage accidents. Because of the large inherent safety margins in the design and construction of spent fuel pools, <u>this issue was RESOLVED and no new requirements were established.</u>* **NUREG-1353, "Regulatory Analysis for the Resolution of Generic Issue 82 'Beyond Design Basis Accidents in Spent Fuel Pools.'"** (U.S. Nuclear Regulatory Commission, April 1989)	The Fukushima Near Term Task Force (NTTF) recommendations, and NRC Orders EA-12-051 and EA-12-049, expose the fact that NUREG-1353 did not resolve the Generic Safety Issue of "Beyond Design Basis Accidents in Spent Fuel Pools." It is unacceptable to base pending or future LR GEIS regulatory conclusions or decisions on Generic Safety Issue 82 and NUREG-1353.
NRC Memorandum: Effect of Fission Product Inventory And Air Ingression On Spent Fuel Pool Accident Consequences (March 29, 2000) And Assessment of Offsite Consequences for a Severe Spent Fuel Pool Accident (SMSAB-99-02) In this memorandum, we concluded that significant air ingression, influencing fission product release, will occur in spent fuel pool accidents involving quick drain-down, and the consequence assessment we performed should accommodate any reasonable uncertainty in the progression of the accident <u>with the possible exception of an increase in the ruthenium release</u>. Small-scale Canadian experiments show that, in an air environment, significant ruthenium releases begin after the oxidation of 75% to 100% of the cladding. For cases with late evacuation (beginning after the fission product release), <u>the effect on prompt fatalities is an increase of one to two orders of magnitude as a result of ruthenium's high radiological dose per curie inhaled relative to that of cesium which was previously the dominant fission product released</u>. We also assessed the effect of ruthenium releases on long-term consequences by-calculating societal dose and cancer fatalities within 100 miles and within 500 miles. The effect of ruthenium releases on societal dose ranged from no increase to a factor-of-two increase. The effect on cancer fatalities ranged from no increase to a factor-of-four increase.	Whenever an NRC research project, such as SMSAB-99-02 and NUREG-1738, refers to "early fatalities" or "prompt fatalities," it is important to recognize which populations are potentially impacted. Virtually all severe accident radiological consequence assessments are limited to off-site populations at some distance from the respective nuclear plant; they fail to assess the on-site consequences. Given that "early fatalities" or "prompt fatalities" could occur off-site, what are the radiological conditions on-site (ground zero)? The on-site (e.g., control room, in-plant, site boundary) radiological consequences of a severe SFP accident may likely impede actions to maintain or restore cooling to the spent fuel and reactor core cooling.

	Reference Appendix B to Part 50, General Design Criterion 19—Control Room and applicable on-site dose regulations.

Draft NUREG-1437 Revision 2 E.3.7 Impact From Accidents at Spent Fuel Pools	Magnuson Comments
Since issuance of the 1996 LR GEIS, additional analysis of the risk from SFP accidents has been performed and documented. These analyses and associated regulatory actions provide further justification for the conclusion that risk from accidents at SFPs is low. For example, in 2001, the NRC published NUREG-1738 (NRC 2001), which evaluated SFP risk during decommissioning.	NUREG-1738 is a “Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants.” The risk at Decommissioning Nuclear Power Plants is not applicable to the License Renewal of operating nuclear power plants. It is unacceptable to base any LR GEIS regulatory conclusions or decisions on NUREG-1738—without explicitly explaining the specific aspects that are applicable to operating nuclear plants.
References	**Reference Comments**
NUREG-1738, Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants: *The end state used for these accident sequences was an SFP water level 3 feet above the top of the*	In isolation, specific aspects of NUREG-1738 appear to be applicable to operating nuclear plants. For example, “*EP was judged to have marginal impact on evacuation effectiveness in the severe earthquakes that dominate SFP risk.*”

fuel. This simplified end state was used because recovery below this level, given failure to recover before reaching this level, was judged to be unlikely given the significant radiation field in and around the SFP at lowered water levels.

The endstate for this analysis is defined as loss of coolant inventory to the point of fuel uncovery from either leakage or boil-off. Dose calculations (Ref. 5) show that when there is less than 3 feet of water above the top of the fuel, an environment that is rapidly lethal to anyone at the edge of the pool can result. Therefore, 3 feet has been adopted as an effective limit for recovery purposes. In other words, the endstate for this analysis is effectively defined as loss of coolant inventory to a point 3 feet above the top of the fuel.

In conjunction with the frequency of the uncovery of the spent fuel, it is important to know the time it takes the fuel to heat up once it has been uncovered fully or partially. Figures 2.1 and 2.2 in Section 2 show the time needed with and without air circulation to heat up the fuel from 30 °C to 900 °C (<u>the temperature at which zirconium oxidation is postulated to become runaway oxidation and at which fission products are expected to be expelled from the fuel and cladding</u>).

The staff realizes that the volumetric rate of air flow that a fuel bundle receives during a loss of cooling event significantly influences the heatup of the bundle. To achieve sufficient long-term air cooling of uncovered spent fuel, two conditions must be met: (1) an air flow path through the bundles must exist, and (2) sufficient SFP building ventilation flow must be provided. The presence of more than about 1 foot of water in the SFP, as in a seismically induced SFP failure or the late states of a boildown sequence, would effectively block the air flow path. Seismically induced collapse of the SFP building into the SFP could have a similar effect. Loss of building ventilation would tend to increase fuel heatup rates and maximum fuel temperatures, as described in Appendix 1A.

In its thermal-hydraulic analysis, documented in Appendix 1A, <u>the staff concluded that it was not feasible, without numerous constraints, to establish a generic decay heat level (and therefore a decay time) beyond which a zirconium fire is physically impossible</u>. Heat removal is very sensitive to these additional constraints, which involve factors such as fuel assembly geometry and SFP rack configuration. However, fuel assembly geometry and rack configuration are plant specific, and both are subject

Emergency Preparedness Evacuation Time Estimates (ETE) are plant-specific. They are a function of Emergency Planning Zone (EPZ) population density and the local infrastructure. It stands to reason, that beyond-design-basis seismic accidents/events could adversely impact local infrastructures; however, there are no regulatory requirements to evaluate evacuation delay times caused by a design-basis or a beyond-design-basis seismic event. Nuclear plants Emergency Preparedness plans are not required to prepare for these types of emergencies, they need only to consider the loss of infrastructure after the fact.

NUREG/CR-7002 (Revision 1), Criteria for Development of Evacuation Time Estimate Studies, states:

"In the unlikely event that the conditions of an EPZ change significantly because of major construction projects, persistent conditions as a result of natural phenomena, or for other reasons, such as a bridge collapse on a primary evacuation route, the licensee should update the ETE analysis if a sensitivity study is not already included in the ETE study."

Given this, undue credit should not be given to Emergency Preparedness evacuations when evaluating beyond-design-basis, seismic SFP accidents. Reference NUREG-2161*, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor*

In any nuclear power plant accident, the off-site radiological consequences (population doses and environmental impacts) are a function of on-site mitigative actions taken, primarily, by main control room operators. For this reason, main control room ventilation systems were 'back' fitted with emergency air filtration systems (NUREG-0737 III.D.3.4, Control Room Habitability) to restore 'compliance' with General Design Criterion 19.

Unfortunately, severe SFP accidents cannot be mitigated from main control rooms. NEI 12-06, Diverse and Flexible Coping Strategies (Flex) Implementation Guide (NRC Order EA-12-049 and EA-12-051) describes SFP accident mitigation strategies, which include actions to route multiple hose sections (hundreds of feet) to use portable pumps to add water to SFP.

to unpredictable changes after an earthquake or cask drop that drains the pool. Therefore, since a non-negligible decay heat source lasts many years and since configurations ensuring sufficient air flow for cooling cannot be assured, the possibility of reaching the zirconium ignition temperature cannot be precluded on a generic basis.	In-plant operators would be required to perform plant-specific time-critical actions under extreme environmental conditions. In addition to the radiological conditions, SFP heat up and boil-off would exacerbate the on-site environmental hazards (e.g., high temperatures, high humidity, steam environments, condensation, poor visibility, etc.).
The change in risk due to relaxation of offsite EP is small because the overall risk is low, and because even under current EP requirements, EP was judged to have marginal impact on evacuation effectiveness in the severe earthquakes that dominate SFP risk.	Whatever natural phenomenon that may have instigated the severe SFP accident would also complicate mitigative actions. The loss of infrastructure caused by seismic events or sub-freezing temperatures would complicate mitigative actions taken by in-plant operators.
Insurance does not lend itself to a "small change in risk" analysis because insurance affects neither the probability nor the consequences of an event. As seen in figure ES-2, as long as a zirconium fire is possible, the long-term consequences of an SFP fire may be significant. These long-term consequences (and risk) decrease very slowly because cesium-1 37 has a half-life of approximately 30 years. The thermal-hydraulic analysis indicates that when air flow has been restricted, such as might occur after a cask drop or major earthquake, the possibility of a fire lasts many years and a criterion of "sufficient cooling to preclude a fire" cannot be defined on a generic basis. Other policy considerations beyond the scope of this technical study will therefore need to be considered for insurance requirements.	In virtually any nuclear accident, it stands to reason that in-plant/on-site radiological consequences would be more adverse than the off-site consequences. This difference must be considered and appropriately evaluated to determine the environmental impacts from severe SFP accidents. Sometime before off-site radiological conditions would cause “early fatalities” or “prompt fatalities,” on-site radiological conditions would incapacitate staff or otherwise delay or, prevent SFP water additions, which could lead to a zirconium fire and result in one or more reactor accidents. .
The staffs risk analyses were complicated by a lack of data on severe-earthquake return frequencies, source term generation in an air environment, and SFP design variability. Although the staff believes that decommissioning rulemaking can proceed on the basis of the current assessment, more research may be useful to reduce uncertainties and to provide insights on operating reactor safety. In particular, the staff believes that research may be useful on source term generation in air, which could also be important to the risk of accidents at operating reactors during shutdowns, when the reactor coolant system and the primary containment may both be open.	Given the Fukushima NTTF recommendations to assess the consequences of multi-reactor/SFP accidents, what are the insurance requirements? Is American Nuclear Insurers (ANI) aware of the consequences of multi-reactor/SFP accidents? Is American Nuclear Insurers (ANI) aware of the consequences of a single SFP accident (i.e., NUREG-2161 Table 33, *Overall Consequence Results?*
The study provides insights for the design and operation of SFP cooling and inventory makeup systems and practices and procedures necessary to ensure high levels of operator performance during off-normal conditions. The study concludes that, with the fulfillment of industry commitments and satisfaction of a number of important staff assumptions, the risks from SFPs can be sufficiently low to evaluate exemptions involving small changes	Given the NRC has not evaluated the consequences of multi-reactor/SFP accidents, how could ANI possible insure nuclear plants for of these accidents? It would be imprudent, if not unlawful, to renew the license of nuclear plants that are under insured. NUREG-1738 does not support classify SFP accidents as Category 1. Additional extracts of NUREG-1738 are listed for future reference.

to risk parameters and to contribute to the basis for related rulemaking. *The analyses in Appendix 1A determined that the amount of time available (after complete fuel uncovery) before a zirconium fire depends on various factors, including decay heat rate, fuel burnup, fuel storage configuration, building ventilation rates and air flow paths, and fuel cladding oxidation rates. While the February 2000 study indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, <u>the revised analyses show that it is not feasible, without numerous constraints, to define a generic decay heat level (and therefore decay time) beyond which a zirconium fire is not physically possible. Heat removal is very sensitive to these constraints, and two of these constraints, fuel assembly geometry and spent fuel pool rack configuration, are plant specific. Both are also subject to unpredictable changes as a result of the severe seismic, cask drop, and possibly other dynamic events which could rapidly drain the pool</u>. Therefore, since the decay heat source remains nonnegligible for flow many years and since configurations that ensure sufficient air[2] for cooling cannot be assured, a zirconium fire cannot be precluded, although the likelihood may be reduced by accident management measures.* *[2]Although a reduced air flow condition could reduce the oxygen levels to a point where a fire would not be possible, there is sufficient uncertainty in the available data as to when this level would be reached and if it could be maintained. It is not possible to predict when a zirconium fire would not occur because of a lack of oxygen. Blockage of the air flow around the fuel could be caused by collapsed structures and/or a partial draindown of the SFP coolant or by reconfiguration of the fuel assemblies during a seismic event or heavy load drop. A loss of SFP building ventilation could also preclude or inhibit effective cooling. As discussed in Appendix 1A, air flow blockage without any recovery actions could result in a near-adiabatic fuel heatup and a zirconium fire even after 5 years.* *Depending on the time since reactor shutdown, fuel burnup, and fuel rack configuration, there may be sufficient decay heat for the fuel clad to heat up, swell, and burst after a loss of pool water. The breach in the clad releases of radioactive gases present in the gap between the fuel and clad. This is called "a gap release" (see Appendix 1 B). If the fuel continues to heat up, the zirconium clad will reach the point of rapid oxidation in air. This reaction of*	

zirconium and air, or zirconium and steam is exothermic (i.e., produces heat). The energy released from the reaction, combined with the fuel's decay energy, can cause the reaction to become self-sustaining and ignite the zirconium. The increase in heat from the oxidation reaction can also raise the temperature in adjacent fuel assemblies and propagate the oxidation reaction. The zirconium fire would result in a significant release of the spent fuel fission products which would be dispersed from the reactor site in the thermal plume from the zirconium fire. Consequence assessments (Appendix 4) have shown that a zirconium fire could have significant latent health effects and resulted in a number of early fatalities. Gap releases from fuel from a reactor that has been shutdown more than a few months involve smaller quantities of radionuclides and, in the absence of a zirconium fire, would only be of concern onsite.	It seems that NUREG-1738 acknowledged the on-site radiological concerns only to dismiss them.

Draft NUREG-1437 Revision 2 **E.3.7 Impact From Accidents at Spent Fuel Pools**	**Comments**
The 2013 LR GEIS considered the risk from severe accidents in SFPs relative to the risk from severe accidents in reactors, including a comparison to the findings in the 1996 LR GEIS. The 2013 LR GEIS concluded that the environmental impacts from accidents at SFPs, as quantified in NUREG-1738 (NRC 2001), can be comparable to those from reactor accidents at full power, as estimated in NUREG-1150 (NRC 1990). *Subsequent analyses performed, and mitigative measures employed since 2001, have further lowered the risk of this class of accidents. In addition, even the conservative estimates from NUREG-1738 are much less than the impacts from full power reactor accidents as estimated in the 1996 LR GEIS.*	NUREG-1738 is a "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants." It is not applicable to the License Renewal of operating nuclear power plants. It is fundamentally unacceptable to base any LR GEIS regulatory conclusions or decisions on NUREG-1738—without explicitly explaining the specific aspects are applicable to operating nuclear plants.
References	**Reference Comments**
NUREG-1150 Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants: *In considering these objectives and the risk analyses in this and supporting contractor reports, it is important to consider both what NUREG-1150 is and what it is not:*	NUREG-1150 does not support the Category 1 classification of SFP accidents. Extracts of NUREG-1150 are included for future reference.

* NUREG-1150 is a snapshot in time of severe accident risks in five specific commercial nuclear power plants. This snapshot is obtained using, in general, PRA techniques and severe accident phenomenological information of the mid-1980's, but with significant advances in certain areas. <u>The plant analyses reflect design and operational information as of roughly March 1988</u>. * NUREG-1150 is an estimate of the actual risks of the five studied plants. It is a set of modern PRAs, having the limitations of all such studies. <u>These limitations relate to the quantitative measurement of certain types of</u> <u>human actions (errors of commission, heroic recovery actions); variations in the licensee's organizational/management safety commitments; failure rates of equipment, especially to common-cause effects such as maintenance, environment, design and construction errors, and aging; sabotage risks; and an incomplete understanding of the physical progression and consequences of core damage accidents.</u> *NUREG-1150 is not the sole basis for making plant-specific or generic regulatory decisions. <u>Such decisions must be more broadly based on information on the extant set of regulatory requirements, reflecting the present level of required safety, cost-benefit studies (in some circumstances), risk analysis results (from this and other relevant PRAs), and other technical and legal considerations.</u> * NUREG-1150 is not an estimate of the risks of all commercial nuclear power plants in the United States or abroad. <u>One of the clear perspectives from this study of severe accident risks and other such studies is that characteristics of design and operation specific to individual plants can have a substantial impact on the estimated risks</u>. Seismic Accident Frequency Analysis Methods: A nuclear power plant is designed to ensure the survival of buildings and emergency safety systems in earthquakes less than one of a specific magnitude (the "safe shutdown" earthquake). In contrast, the analysis of seismic risk requires consideration of the range of possible earthquakes, including those of magnitudes less than and greater than the safe shutdown earthquake. Seismic risk is obtained by combining the frequencies of the spectrum of possible earthquakes, <u>their potential (and very uncertain) effects on equipment and structures within the plant under study</u>, and the subsequent effects on	

core and containment building integrity. In considering this, <u>it should be noted that during an earthquake, all parts of the plant are excited simultaneously</u>. Thus, during an earthquake, redundant safety system components experience highly correlated base motion, and <u>there is a high likelihood that multiple redundant components would be damaged if one is damaged. Hence, the "planned-for" redundancy of equipment could be compromised. This common-cause failure mechanism represents a potentially significant risk to nuclear power plants during earthquakes</u>. *The scope of NUREG-1150 is narrowly defined, making the risk study incomplete. Many types of accident initiators are unaccounted for, including earthquakes, floods, and other external events; reactor coolant pump seal failure; steam generator tube ruptures; and instrument air losses. Other phases of plant operation need to be considered in addition to normal full-power operation, including power ascension and descension; shutdown; and operation with Mark I containment buildings de-inerted. <u>Accidents in spent fuel pools should be taken into account</u>.* *To confirm that the scope is appropriate, the NRC is initiating a separate study of the risk associated with low power and shutdown conditions for two of the plants studied in NUREG-1150. The results are expected to be available in FY 1990. <u>The risk associated with spent fuel pool accidents is being assessed separately in studies responding to NRC's Generic Issue 82, "Beyond Design Bases Accidents in Spent Fuel Pools</u>." When completed, these will be examined to determine if further efforts are advisable.*	

Draft NUREG-1437 Revision 2 **E.3.7 Impact From Accidents at Spent Fuel Pools**	**Comments**

More recent analysis demonstrates even lower risk and safety improvements. For example, the NRC performed a consequence study in NUREG-2161, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor (NRC 2014a), referred to as the Spent Fuel Pool (SFP) Study, to continue its examination of the risks and consequences of postulated SFP accidents. *NUREG-2161 (NRC 2014a) provides publicly available consequence estimates of a hypothetical SFP accident initiated by a low-likelihood seismic event at a <u>specific reference plant</u>. The study compares high-density and low-density loading conditions and assesses the benefits of post-9/11 mitigation measures.* *The NUREG-2161 results are consistent with earlier research conclusions that SFPs are <u>robust</u> structures that are <u>likely</u> to withstand severe earthquakes without leaking. The NRC continues to <u>believe</u>, based on this study and previous studies, that high-density storage of spent fuel in pools protects public health and safety.*	Contrary to Draft NUREG-1437 Revision 2, NUREG-2161 does not necessarily demonstrate lower risk of severe SFP accidents. Among its limitations, NUREG-2161 does not asses multi-reactor/SFP accidents. The plant-specific qualifications made in NUREG-2161 do not support classifying SFP accidents as Category 1. NUREG-2161 results are consistent with earlier research conclusions that rely on the seismically 'robust' contravention; however, the results defy reason. Claiming that the storage of high volumes of hazardous, irradiated fuel in spent fuel pools "*protects public health and safety* is nonsense and an insult to the intelligence of the reader and the public. -Public comment by Janet Novotny Reference NUREG-2161 Table 33, *Overall Consequence Results*, copied below, and the NUREG-2161 extracts that refer to high-density storage. Please see the Reference Comments below.
References	**Reference Comments**

NUREG-2161, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: *The study uses best-estimate ruthenium release rates calculated by the MELCOR code. These release rates are most similar to the low ruthenium release case from NUREG-1738.* *For the high-density cases, the releases are limited to a few percent of the cesium inventory, except for a few cases that predicted hydrogen combustion and resulted in releases of one to two orders of magnitude higher than the other cases. In these cases, the spent fuel heats up in a steam environment leading to oxidation of zirconium and releasing hydrogen gas into the reactor building. The mixing and reaction of hydrogen and oxygen leads to a hydrogen combustion and substantially damages the reactor building. That damage could breach structures that would retain radioactive material, along with allowing more oxygen into the building, potentially increasing the severity of the spent fuel fire.* *The additional water can have a non-intuitive negative impact in certain situations. For a leak at the bottom of the SFP, the additional water at the elevation of the fuel causes it to take longer to "clear" the baseplate (i.e., for the level of the receding water to drop below the bottom of the baseplate). In situations where natural circulation of air under and up through the racks is effective for preventing fuel heatup, this actually temporarily inhibits cooling of the fuel.* *In the context of a seismic event, the elevation of the pool will affect the transmission of seismic loads through the structure, can potentially inhibit accessibility for taking mitigative action, and can potentially lead to flooding of safety-related equipment, if the pool and surrounding structures are significantly damaged.* *In reality, there are differences between the major design types (PWRs versus BWRs) that make each more or less susceptible to SFP accidents on a scenario-specific basis. Similarly, the selection of a site that has a separate SFP for each reactor (as opposed to a shared pool) is also not intended to suggest that these situations are inherently more vulnerable.* *Because this study strives to be site-specific, it does not account for the variability in design and operation across the operating fleet, but rather, represents one point within that spectrum (Unit #3 of the Peach Bottom Atomic Power Station (PBAPS), circa 2011.)* *Qualitative arguments are provided to show that the likelihood of core damage from SFP boiling accidents is low for most U.S. commercial nuclear power plants. The INL study also showed that, depending on the design characteristics of a given plant, the likelihood of either (1) core damage from SFP-associated flooding or (2) spent fuel damage from pool dryout may not be negligible.*	NUREG-2161 excluded the high ruthenium release case from NUREG-1738 to remove "prompt fatalities" from the potential consequences of severe SFP accidents. This omission does not reflect a "hard look" at the environmental impacts of severe SFP accidents. -i.e., hydrogen explosion SFP failures, at most BWR plants, would resulting internal flooding of the reactor building with radioactive water.

The study focuses on the SFP, <u>not the reactor</u>, though for instances in which the two are hydraulically connected, both are considered to a certain extent. *Item #(5)—<u>effects of a concurrent reactor accident—generally have not been studied in prior efforts</u>. <u>The frequency and consequences of a reactor accident is not considered and the effect of a reactor accident on a spent fuel pool scenario is partially considered here, but not rigorously</u>.* *Multi-unit / concurrent reactor accidents are not, in general, considered. Specifically, <u>the reactor (and its decay heat) is treated during the outage until the level in the reactor well / SFP drops to below the bottom of the fuel transfer canal. Beyond that point, and in all portions of the post-outage scenarios, the reactor is not considered as a source of steam, fission products or hydrogen</u>.* *Inadvertent criticality events are not considered.* *Seismic hazard models - this study used the existing USGS 2008 model instead of the model in the ongoing program. While <u>the USGS (2008) hazard model is not sufficiently detailed for regulatory decisions</u>, it is appropriate to use for this study because it was the most recent and readily available hazard model for the selected site at the start of the study.* *No significant debris generated by the seismic event enters the SFP. - Based on the expected structural response of the building, overhead crane, etc. there is no expectation that heavy debris that would damage the pool and fuel will be generated as a direct result of the seismic event itself.* *<u>The seals of the refueling gate do not fail. -Finite element analysis does not predict large deformations in this area that would suggest such an event is likely</u>. Details of the gates provided by the licensee show that there are two gates with a gap in between and that each gate has mechanical seals to prevent leakage. These seals are kept under pressure by passive mechanical means (i.e., do not depend on air pressure, ac power, or dc power) <u>that are unlikely to fail under the earthquake.</u>* *Failure of nearby dams is not explicitly addressed.* *50.54(hh)(2) mitigation capacities (i.e., 500 gpm makeup delivered or 200 gpm spray delivered) are based on the generic NRC endorsed capacities in NEI-06-12, Revision 2.* *The study does not consider debris entering the pool as a result of any modeled hydrogen combustion event. Such debris could be generated and could fall into the pool. However, the occurrence of a hydrogen combustion event in this study denotes that the fuel in the SFP has already become uncovered and is undergoing a fission product release. Thus, debris would primarily serve to inhibit longer term recovery actions not considered in this study. The occurrence of a hydrogen combustion*	The NRC NTTF acknowledges the reality of multi-reactor/SFP accidents, but the NRC has yet evaluated the radiological and environmental consequences of multiunit accidents. The Fukushima NTTF states: "While the U.S. EP framework has always noted that the plume exposure pathway EPZ provides a basis for expansion, insights from real-world implementation at Fukushima, <u>including the realities of multiunit events</u>, might further enhance U.S. preparedness for such an event. The Task Force acknowledges that every situation will differ, so <u>detailed preplanning in this area is not plausible</u>." A review of NUREG-2161 Table 33, *Overall Consequence Results,* may explain why the preplanning of a SFP accident the ultimately displacement of 4.1 million people would be problematic. NUREG-2161 assumptions, admittedly, omit credible consequences of multi-reactor/SFP accidents and beyond-design-basis seismic events that induce SFP structure accidents. NUREG-2161 choose to ignore the fact that

event from a concurrent reactor accident has the potential to generate debris which could impair SFP natural circulation air or steam cooling (should the fuel in the SFP become uncovered) for conditions in which the fuel might otherwise be cooled by means of these passive cooling modes. However, this latter situation is inherently tied to the study's lack of a comprehensive treatment of multiunit aspects.

The study does not consider the effects of molten core-concrete interaction (MCCI). - The MELCOR code models heat transfer from the debris to the pool floor, as well as the fission product release from hot debris. In some cases, the debris temperature remains above typical concrete ablation temperatures (~1500 K). MCCI may occur in selected scenarios in which the fuel relocated to the bottom of the pool following the failure of the rack baseplate and its temperature exceeded the concrete ablation temperature. These cases involve large-scale debris relocation and large releases of volatile fission products. Even without MCCI, the fuel in debris form continues to release fission products resulting in very large releases of volatiles.

Calculated results are from atmospheric-type releases only.

The seismic event has a limited effect on emergency response. -- The study assumed that the seismic event would not significantly affect emergency response. This is based on an assessment in NUREG-1935 of the same site and seismic event that assumed the damage to local infrastructure is limited to 12 bridges, partly due to the few large structures in the area. Also, the extended loss of ac power is assumed to be limited to the EPZ (~10 miles) due to the assumption that the strength of the seismic event is from the proximity of the seismic event to the site, rather than being a wider impact from a larger magnitude.

Decontamination will occur only if it will eventually allow for the return of land to habitability, and if it is economic to do so. -- A long-term cleanup policy for severe accidents does not currently exist, although guidance is currently being drafted. In addition, guidance could recommend the development of localized cleanup goals after an accident, to account for sociopolitical, technical, and economic considerations. Given that a policy for long-term cleanup does not currently exist (and because a developed policy may not contain explicit cleanup goals), the project instead uses dose levels associated with habitability to decide what land is to be decontaminated.

Observations Regarding a Multiunit Event:

There are four broad interplays that can be defined between the SFP and the reactor:
(1) an initiating event that directly affects both the reactor and the SFP
(2) a reactor accident that prevents accessibility to the SFP for a prolonged period of time (e.g., due to high radiation fields), leading to a SFP accident
(3) a reactor accident that includes ex-containment energetic events (e.g., a hydrogen combustion event) or other ex-containment interplays (e.g., steaming through the drywell head that affects refuel floor combustible gas mixtures) and creates a hazard to the SFP (e.g., by causing debris to fall in to the pool) or otherwise changes the SFP event progression[5]

The NRC knows that fuel pool gate and cavity seals have failed. They documented these failures in NUREG-1275. Given that failures occurred without a seismic event, it is wrong of the NRC to assume that SFP gates will not leak in a beyond-design-basis earthquake.

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Finally, inventory loss could occur directly owing to SFP liner leakage or gross failure of the SFP structure. The impacts of a dropped heavy (a load weighing more than one fuel assembly) load or a seismic event are potential causes of gross failure, although SFPs are designed to survive seismic events. Radiological and structural response and makeup capability for dropped light loads (those weighing no more than a fuel assembly) are bounded by analyses of a fuel handling accident. On the other hand, dropped heavy loads have the potential to exceed the design basis of the fuel pool structure and the make-up system.

A more likely sequence would be a loss of inventory through a gate or seal that would terminate when the level reached the elevation of the leak. Then, because of the decreased inventory of water in the SFP and the loss of suction to the SFP cooling system, the remaining water in the pool would boil away until the fuel was uncovered.

(4) an SFP accident that prevents accessibility to key reactor systems and components for a prolonged period of time or which creates a hazard for equipment used to cool the reactor (e.g., the flooding of low elevations of the reactor building due to a leak in the pool or excessive condensation from continuous boiling of SFP water), leading to a reactor accident. *For each of these interplays, large seismic events and severe weather SBO events are logically the most relevant initiators, as <u>they are the type of initiators that are most likely to initiate an accident at the reactor and SFP, while simultaneously hampering further accessibility to key areas, key systems and components, and key resources</u>.* *<u>Along with the possibility of a concurrent SFP and reactor accident, there is the possibility for a concurrent accident at the SFP of one unit with an accident at the SFP or reactor of the other unit. Again, a large seismic event or a severe weather SBO are the events that are most likely to lead to a multiunit event</u>. In general, if accidents at both SFPs proceed in similar manners and similar timeframes, and both pools have similar inventories of spent fuel, then the resulting source term from a dual-unit event would be roughly twice the single-unit source term. In reality, this type of perfect symmetry is unlikely because the two (or more) SFPs are very unlikely to have the same total pool heat load or peak assembly heat load. (Recall that for multiunit sites, the reactors did not usually start operation at the same time and outages are intentionally staggered.) Even if this symmetry did exist, the offsite consequences would not follow a linear scaling because of a number of nonlinearities associated with that portion of the analysis. Again, <u>capturing these effects was not a focus of this study, and future work (the SECY-11-0089 Level 3 PRA) will attempt to more rigorously treat these effects</u>.* *2.3 Inadvertent Criticality:* *Inadvertent criticality events (ICEs) may be possible for specific combinations of conditions (e.g., during reflood of a drained pool for a region of the pool storing higher reactivity fuel assemblies where the boron poison in the rack panels has been significantly displaced as a result of the earthquake). If such an event affected a region of the pool (as opposed to only a portion of a particular assembly), and if it occurred at a point in the accident where the fuel was only partially covered, the event could have an important impact on onsite dose rates. Further, if an ICE were severe enough to produce significant heat, the fuel will be harder to cool and short-lived radionuclides will be produced. Design requirements and safety analyses ensure that the spent fuel stored in the pool, under <u>normal</u> conditions, will not result in a critical configuration.* *"Advantageous" considerations, including the following:* *• BWR SFPs do not use borated water so the fact that the SFP may be refilled with unborated water is not a deviation from the norm.* *Counter considerations:* *• <u>The poison material in the rack panels contribute significantly to the net reactivity of the SFP configuration (i.e., they are a key component to ensuring subcriticality for high reactivity assemblies).</u>* *<u>• The effects of large seismic events on already degraded SFP rack poison material are not easy to quantify.</u>*	*Loss of SFP coolant inventory events for which corrective actions are taken before severe consequences occur can potentially cause other problems. Even a minor loss of SFP coolant inventory can lead to loss of SFP cooling because the lower SFP level causes loss of* *suction to the SFP cooling system. Losses of SFP coolant inventory may produce flooding or environmental problems in other areas of the plant. Ventilation and drain systems can transport water and steam to other parts of the plant and affect emergency equipment. A significant amount of water vapor may be generated either by direct boiling or evaporation from the SFP. Various SFP equipment and* *ventilation configurations may allow the water vapor to accumulate on SEP cooling equipment and cause it to fail, further exacerbating the loss of inventory.* *Where the SFP area atmospheric water vapor can be transported to areas which house other that equipment important to safety,* *Equipment may be affected. This potential problem is multiunit sites during and important in some immediately following full core off-loads. In these units, the fuel pool atmospheric water vapor from the unit refueling can be transported to areas housing safety equipment when the unit near full power. This transport is operating at or could cause equipment required for a safe shutdown of the operating unit to be damaged or to fail.*

• The rack panels and poison material have a lower melting temperature than the cladding and fuel. *• Termination of a SFP ICE during an event that required deployment of mitigation equipment could be difficult.*	
• The possibility of a criticality event cannot be summarily dismissed.	What is the basis for not considering the consequences of a hydrogen explosion or other credible events?
Finally, the offsite consequences of a criticality event (especially if it occurs when overlying water is present) are believed to be less severe from a public health and safety standpoint than the offsite consequences from a potential large release of radioactive material associated with a prolonged uncovering of the fuel in the SFP resulting from not attempting to reflood. In consideration of all of the above, common accident management practices in the United States call for the use of any available water in responding to fuel uncovery in either the reactor or SFP. This study shows the precedent, while recommending that future work be done to better understand the specific combinations of conditions that could lead to ICEs during a large seismic event. *Damage States for the Spent Fuel Pool Structure* *Define three initial states for the subsequent accident progression analysis as follows:* *(a) A state with no leakage, and no loss of coolant, from the bottom of the SFP. This state corresponds to concrete cracking at the base of the walls (estimated to be through-wall cracking for the event considered as shown in subsequent subsections) but without tearing of the liner.* *(b) A state with moderate leakage rate from the bottom of the SFP, corresponding to through-wall concrete cracking at the bottom of the walls with tearing of the liner that propagates to an extent such that water leakage is controlled by the size of the cracks in the concrete.* *(c) A state with small leakage rate from the bottom of the SFP, corresponding to through-wall concrete cracking at the bottom of the walls and tearing of the liner that remains localized such that water leakage is controlled by the size of the tearing in the liner.* *Other Damage States* *Assessment of other damage stages is primarily based on (1) finite element deterministic response spectra analysis to estimate maximum vertical displacements of the water surface (sloshing), (2) seismic fragilities used in conjunction with the NUREG-1150 seismic PRA study (Lambright et al., 1990), (3) the examination of design details for certain appurtenances such as the refueling gate, and (4) maximum displacements (vertical and horizontal) of the SFP floors and walls under the applied loads.* *Damage to Refuel Gate, SFP Penetrations, Spent Fuel Assemblies and Racks* *Refuel gate: A site visit and examination of the refueling gate structural drawings revealed the following:* *• The steel gate next to the water is backed by a similar gate.* *• Each of these gates consists of a steel-plated decking with steel stiffeners.*	

• Each gate has a polymeric seal around its perimeter that is pressed against the concrete by passive mechanical means that are not expected to be lost during the seismic event. Since these are passive mechanical means the effectiveness of the seals does not depend on the availability of ac or dc power. *• Tolerances around the seals are sufficient to accommodate the already small distortions of the biological concrete shielding in the refueling area from the seismic event.* *Based on the above, the study assumes that the refueling gate will not fail <u>for the seismic event considered</u> and will continue to maintain its intended function during the accident progression.* *Spent fuel racks and assemblies: <u>Damage to the spent fuel assemblies and racks was not calculated as part of this study</u>. The study assumes that under the applied seismic loads a coolable configuration would be maintained. This assumption is consistent with the seismic assessments made in conjunction with the resolution of GI-82 and reported in NUREG/CR-5176 (Prassinos et al., 1989). As in the case considered in GI-82, the spent fuel racks for the site considered are allowed to slide, which tends to reduce the magnitude of the seismic accelerations on the racks and partially decouple their dynamic response from the response of the SFP. In addition, the high-frequency components (greater than 10 Hz) of the motion would not be expected to induce large sliding or rocking motions.* ***Treatment of Mitigation*** *One of the objectives of this study is to provide insights into the effectiveness and benefits of mitigation measures currently employed at nuclear power plants. In addition to the redundant and diverse physical systems designed to prevent severe accidents, NRC requires plant owners to have preplanned emergency measures in the unlikely event an accident occurs.* *When they are successfully implemented, NRC expects these emergency measures will mitigate accident consequences by preventing, delaying, or reducing a potential release of radioactive material from the SFP. These measures include a site-specific emergency plan, emergency operating procedures, severe accident management guidelines, and 10 CFR 50.54(hh)(2) mitigation measures put in place to respond to the loss of large areas of the plant due to fires or explosions.* *NRC requires its licensees to train and practice emergency measures to ensure that they have proper equipment, procedures, and training. NRC inspectors periodically observe these activities to help ensure that NRC regulations are met at each plant. <u>The study assumes that the licensee's emergency response organization would implement these measures in accordance with approved emergency plans, procedures, and guidelines</u>.* *<u>The uncertainties associated with the response to a beyond design-basis seismic event, and the resultant effects on the SFP, make consideration of unmitigated scenarios prudent from an informed decision-making standpoint</u>.*	Missing from NUREG-2161 is the disadvantage or courter consideration that exist at PWR plants that borate their SFP. It seems the consequences of a concurrent SFP and reactor accident, and a concurrent accident at the SFP of one unit with an accident at the SFP or reactor of the other unit, should be assessed to determine the environmental impacts.

However, for the large beyond-design-basis seismic event under consideration in this study, it is possible that significant damage to local infrastructure could occur, requiring emergency resources to also be needed in other areas. Additionally, *radiation and other hazards* (discussed in Section 5.3.2 of this report) *could hinder access to the SFP and key equipment, making prevention or truncation of an ongoing SFP release challenging.* ***Rationale for Producing Unmitigated Results*** *The large seismic event could damage onsite (and offsite) infrastructure designed to facilitate accident response, as well as cause general disruption at the site.* *• If circumstances led to the uncovery of fuel in the SFP, radiation fields on the refueling floor might hamper mitigative actions.* • *A concurrent reactor event (resulting from the loss of ac power or other damage), or an ongoing accident at the other unit's SFP, could hamper mitigative actions by reducing accessibility because of radiation fields, impeding accessibility because of other hazards such as hydrogen accumulation, or diverting resources (both personnel and equipment).*	Given that spent fuel racks and their poison material have a lower melting temperature than the cladding and the fuel, mitigative actions to resubmerge or spray water on spent fuel may result in criticality—which is extremely problematic. Could SFP criticality be prevented without allowing the SFP to dry out and creatr a zirconium fire?
Refueling Floor Dose Rate Analysis Using SCALE *This study included analyses to predict the radiological conditions on the refuel floor for a range of conditions associated with loss of water in the SFP. Note that the analyses described in this section only account for the radiological conditions stemming from neutron and gamma "shine" from exposed radioactive material and do not account for the concern of radiological conditions associated with the release of that material following fuel heatup. It is expected that, if a radiological release of fission products from the SFP were to commence, radiation fields in the vicinity of the pool would be extremely high.* ***Discussion of Repair and Recovery*** *This study makes no attempt to account for repair or recovery of onsite equipment or offsite power. This is a simplifying assumption, and is motivated in part by the lack of quantitative information available to support such a determination for the large seismic event being considered. Procedures would direct the operators to attempt to recover failed equipment and pursue alternate means of establishing ac power, such as the ability to obtain ac power from an SBO cross-tie line to the Conowingo Dam. The study assumes that the damage sustained by the onsite and offsite electrical distribution systems from the earthquake is enough to significantly delay these recoveries until after the 48- or 72-hour truncation times. That being said, and as covered previously in this section, the scenarios with successful deployment of mitigation do assume that onsite and offsite resources are able to extend operation of the 10 CFR 50.54(hh)(2) equipment indefinitely, which could represent a situation in which ac power is recovered at an intermediate point and ac-dependent means of SFP makeup are brought back online.* *Identification of Key Events* *• The 10 CFR 50.54(hh)(2) equipment (when credited) is available for the duration of the event, following delays associated with diagnosis and deployment.* *• Initial water loss from "sloshing" will be 0.5 m (1.5 ft) (see Section 4.2 of this report).*	NUREG-2161 describes the SFP modeled in MELCOR: *The SFP, 40 ft (12.2 m) wide by 35.3 ft (10.8 m) long by 38.75 ft (11.8 m) deep, is located on the refueling floor of the reactor building. The pool is constructed of reinforced concrete with a wall and floor lining of 1/4-in.-(0.63-cm-) thick stainless steel. The walls and the floor of the SFP are approximately 6 ft (1.83 m) thick.* In each damage state analyzed, NUREG-2161 assumes 6 ft thick reinforced concrete SFP walls would crack completely through. After the earthquake at Fukushima, it seems imprudent to assess the consequences of beyond-design-basis seismic SFP failure using a 1990 PRA study.

• Tearing of the SFP liner is not the most probable outcome, but is possible. *• There is no failure of penetrations, including the refueling transfer canal gate.* *• The overhead structures (building debris, crane) do not pose a threat to the SFP in terms of failure resulting from the initiating event.* *• Inadvertent criticality, including seismic effects on the integrated poison rack material, is not treated.* *A complete reactor building has been developed for the reference plant (NRC, 2012d). However, the bulk of the reactor building does not play a significant role in SFP accidents, given that the study does not explicitly model (1) the effect of the SFP accident on reactor systems or (2) specific obstacles to deploying mitigation (e.g., presence of steam on lower elevations). Consequently, the reactor building model was simplified to only model the refueling room.*	Without specifying seismic category of SFP gates, NUREG-2161 leads the reader to believe that steel-plated decking with steel stiffeners (SFP gates) will not fail in a seismic event that causes 6 ft thick reinforced concrete walls to fail. This seems implausible. The size and construction of SFP gates vary. Some SFP are designed such that the depth of SFP gates is above the elevation the spent fuel racks. This design considers the failure of SFP gates and prevents the uncovery of spent fuel should they fail. Other SFP designs would allow spent fuel to be uncovered if the gates fail. In both designs, the SFP gates are a vulnerability. Seismic failure of SFP gates may rapidly drain the SFP to within a few feet of spent fuel or rapidly uncover spent fuel. Reference the SFP and reactor cavity draining events documented in NUREG-1275 (Vol. 12) *Operating Experience Feedback Report - Assessment of Spent Fuel Cooling.*
Emergency Response Modeling *Since actions beyond the emergency planning zone (EPZ) would be ad hoc, there is no procedural guidance or exercise performance documentation upon which to base assumptions.* *For each of the accident sequences, staff determined that a General Emergency would be declared promptly (within 15 minutes), based on the emergency action levels for the operating reactor. The timing of significant radiological release varied among the accident sequences and was an important factor in the response modeling. A release from a SFP with a moderate leak begins earlier than a damage state with a small*	It is unreasonable and fundamentally wrong to assume that Non-Seismic Category I SFP structures (and components)—that are not designed to remain functional during a design-basis earthquake—would remain

leak, but these still do not begin until evacuation is well underway or completed within the EPZ. *General Public Evacuation: Residents evacuate the affected area when the official order to evacuate is received.* *Early Evacuation: Residents evacuate after the earthquake, but before the official order to evacuate is received.* *The MACCS2 potassium iodide (KI) model used in this analysis assumes that KI would be distributed only within the EPZ. Half the residents within the EPZ are assumed to have access to their KI and to take it within the specified timeframe.* *The seismic event is assumed to cause the loss of all onsite and offsite power within the EPZ, which can affect the response timing and actions of the public. Sirens would be sounded following the GE declaration, and because the reference plant will have a fully backed up siren system in 2013, it is assumed sirens sound for this analysis. The residents within the EPZ would have felt the earthquake, which effectively serves as the initial warning; however, the loss of power would affect the number of residents receiving instructions via emergency alert system messaging. It is expected that the residents use multiple methods of communication, such as cell phones, telephones, websites (where power is available), and direct interface to communicate the emergency message.* *A long-term cleanup policy for recovery after a severe accident does not currently exist. The actual decisions regarding how land would be recovered and populations relocated after an accident would be decided by a number of local, state, and federal jurisdictions and would most likely be based on a long-term cleanup strategy, which is currently being developed by the NRC, EPA, and other Federal agencies. Furthermore, a cleanup standard may not have an explicit dose level for cleanup.*	functional during a beyond-design-basis (worse) earthquake. It is impractical, if not impossible, to physically reinforce Non-Seismic Category I SFP structures (and components), such that they would could satisfy remain functional during a design-basis earthquake. The same is true for Seismic Category I SFP structures (and components)—such that they would remain functional during a beyond-design-basis earthquake. Ultimately, there are no feasible engineering solutions that would protect people and the environment from beyond-design-basis seismic SFP accidents. This is why the nuclear industry concocted the seismically 'robust' contravention. Spent fuel damage caused by a seismic event or seismic debris would result in the immediate release of noble gasses, that may limit or prevent mitigative actions. Refence NRC Information Notice 90-08, Kr-85 Hazards From Decayed Fuel. What is the seismic category of spent fuel racks that are allowed to slide in a seismic event? 10 CFR 50.54(hh)(2) mitigation measures are not applicable to seismic events. It is unreasonable to assume that portable non-seismic equipment would survive a beyond-design-basis seismic event.

Instead, the cleanup strategy may give local jurisdictions the ability to develop localized cleanup goals after an accident, to allow for a number of factors that include sociopolitical, technical, and economic considerations. *[8] Largest releases here are associated with small leaks (although sensitivity results show large releases are possible from moderate leaks). Assuming no complications from other SFPs/reactors or shortage of available equipment/staff, Section 8 shows that there is a good chance to mitigate the small leak event.* ***7.2.1 Individual Early Fatality Risk*** *For all scenarios, no offsite early fatalities attributable to acute radiation exposure are predicted to occur. Due to radioactive decay, spent fuel pools tend to have significantly less shorter-lived radionuclides (e.g. I-131) than reactors. Despite this, in at least one case that was analyzed, doses close to the site did reach levels that can induce early fatalities. Therefore, the potential (although remote) for early fatalities exists. However, emergency response as treated in this study effectively prevents any early fatality risk from acute radiation exposure, at least in part because the modeled accident progression results in releases that*	As described in NEI 12-06, the (EA-12-049) FLEX strategies assume (1) "*all boundaries of the SFP are intact, including the liner, gates, transfer canals,"* and (2) *"although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool."* FLEX (NEI 12-06) equipment and strategies are insufficient to mitigate SFP failure/draining accidents.

are long compared to the implementation of emergency response in the areas of most concern. *The projections of no early fatalities in this study is lower than that reported in some previous studies of risks from spent fuel pool accidents, such as NUREG/CR-6451 and NUREG-1738, and consistent with the earlier studies documented in NUREG-1353. Tables 4.1 and 4.2 of NUREG/CR-6451 project anywhere from approximately one to one hundred early fatalities within a 500 mile radius in the event of an accident involving the full spent fuel pool, with the higher values associated with high release fractions. NUREG-1738 (Table 3.7-1 and Table 3.7-2) reported similar values, ranging from no fatalities for low Ruthenium source terms with early evacuation to up to 192 early fatalities for an accident shortly (30 days) after shutdown with high Ruthenium source terms and late evacuation. NUREG-1353 does not provide quantitative estimates of early fatality risk but states that "…there are no "early" fatalities and the risk of early injury is negligible". On balance, the scenarios analyzed here are consistent with the lower end of the reported range from previous studies, in that no early fatalities are projected to occur.* ***7.2.3 Land Contamination*** *As the values in Table 33 suggest, conditional on a release (with a frequency of 1E-7 per year, or lower) occurring, the total land contamination area can be considerable. The low-frequency, large releases are significantly affected by hydrogen combustion events, which are currently predicted in some high-density loading situations without successful mitigation for 3 days, but not in other scenarios. For relatively small releases from a SFP, the extent of contaminated land could range to hundreds of square miles. For a large release, such as a release from a high-density pool without successful deployment of 50.54(hh)(2) mitigation that leads to a hydrogen combustion event, the amount of contaminated land can be two orders of magnitude higher (Table 35 partially reflects this range, although it reports average values). The levels of potential land contamination in the event of a release should be weighed against the likelihood of the accident.* *A release in the high-density fuel loading situation without successful 50.54(hh)(2) mitigation is capable of large releases, and therefore an average release from this situation is capable of causing significantly more land contamination at longer distances than in the other situations.*	In addition to neutron and gamma shine, seismic induced spent fuel damage would release of noble gasses, resulting in potentially large inhalation doses that may delay or prevent mitigative actions.

In contrast, releases from situations with low density fuel loading (and/or successfully deployed 50.54(hh)(2) mitigation equipment) cause a relatively smaller amount of land contamination beyond 50 miles, and none beyond 100 miles when using land interdiction as a measurement of land contamination. This is because on average, a release in these situations contaminates significantly less area. However, because of the release magnitude of any of the analyzed SFP releases, the total amount of land contamination that remains within ten miles is relatively small.

On land contamination, past results are expected to be broadly consistent with this study. However some previous studies did not report land contamination and some reported different metrics for estimating areas, so a direct comparison is not possible. NUREG/CR-6451 reports values for condemned farmland that includes hundreds of square miles within a 50-mile radius and thousands of square miles within a 500 mile radius, albeit for a full core off-load. NUREG-1353 reports values for land contamination based on NUREG/CR-4982 that range into the hundreds of square miles, albeit largely within a 50-mile radius of the plant. These differences, as well as different choices for the land contamination criteria that can significantly affect the estimated areas, make a quantitative comparison less meaningful. However, it is clear that both this study and past studies have predicted that SFP accidents can lead to significant land contamination.

7.2.4 Displaced Individuals

Consistent with the results for land contamination, relatively large numbers of people may be impacted following a large release from a spent fuel pool. Displaced individuals, also known as relocated individuals, are people who are predicted to be temporarily or permanently relocated due to interdiction of contaminated land, based on the dose limit for land interdiction starting in the first year following an accident. These individuals are not necessarily the same as evacuees, who evacuate during the emergency phase (although an individual could be both of these).

Conditional on a release (with a frequency of 1E-7 per year or lower) occurring, the total number of temporarily relocated individuals could be considerable. For relatively small releases of an SFP, the number of displaced individuals could range into the hundreds of thousands. For a large release, which is predicted in some high-density loading situations early in the operating cycle without successful 50.54(hh)(2) mitigation, the number of displaced individuals can be two orders of magnitude higher. (Table 36 partially reflects this range, although it reports average values).

Also consistent with the observations related to the amount of land contamination with distance, the results of the analysis indicate that protective actions such as temporary relocation may be needed at long distances. The table below displays the average number of displaced individuals for different distances for high (1x4) and low density fuel loading.

"Early evacuation" seems misleading. It seems unlikely that residents, harmed or otherwise 'distracted' by a major earthquake (beyond-design-basis) would evacuate away from a nuclear plant before they were somehow notified to evacuate.

The loss of infrastructure would likely delay any evacuations.

The standard Emergency Planning Zone (EPZ) is a 10-radius from the respective nuclear plant.

NUREG-2161 states: "*Since actions beyond the emergency planning zone (EPZ) would be ad hoc, there is no procedural guidance or exercise performance documentation upon which to base assumptions."*

Shelter in Place, offers limited protection from inhalation doses for a short period of time.

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Contrary to what might be expected, 50.54(hh)(2) mitigation is predicted to slightly increase the average conditional consequences of a release from a low-density fuel loading pattern. While successful deployment of 50.54(hh)(2) equipment is usually effective at preventing releases, it is not as effective at mitigating release from the low-density fuel loading pattern when deployed in a capacity specifically to provide makeup water through injection, as sometimes assumed. In these conditions, release from a SFP can sometimes be somewhat larger with deployed mitigation. In addition, the situations for which 50.54(hh)(2) equipment prevented release for the low-density loading events were the situations with the smallest release magnitudes, which has the non-intuitive effect of increasing the average consequence of a release.

8.1.2 Key Factors Affecting Available Time for Mitigation

The SFPS groups the SFP damage caused by the earthquake into three classes: (1) no leakage, (2) small leakage, and (3) moderate leakage with a corresponding conditional probability of 90 percent, 5 percent, and 5 percent, respectively. The small leakage scenario is represented by 40 small tears in the stainless steel liner at the backup bar locations. The small cracks create an initial leakage rate of about 250 gpm. The leakage flow rate depends on the SFP water level. As the SFP water level decreases, the leakage rate reduces. The moderate leakage is represented by a long crack with a combination of the stainless steel SFP liner tear and a through-wall concrete crack at the bottom of the SFP wall. Section 4.1.5 of this report discusses the SFPS damage states in detail. The moderate leak creates an initial leakage rate of about 1,900 gpm. The HRA assumes that the SFP leak rate affects the available time necessary for mitigation because, when the SFP fuel is not covered by water, the radiation level at the locations in which mitigative equipment is stored and mitigative actions are performed is assumed to be too high for performance of the mitigative actions in this study. Thus, the SFP leak rate directly affects the SFP fuel uncovery time. Table 41 shows the time to SFP fuel uncovery in the various scenarios.

Evacuations out to 30 miles may likely involve large population centers.

Overall, it seems that Emergency Preparedness evacuations would provide little benefit or protection of the public in the event of a beyond-design-basis single SFP accident.

Reference NUREG-2161 Table 33.

Figure 98 shows the approximate dose rate contours in the refueling area at the time of defueling when the SFP water level is at the top of the fuel rack. The radiation at the mitigation equipment storage location ranges from 3–30 rem per hour and the radiation level at the locations of the spray nozzles for SFP makeup is in the range of 10 to 300 rem per hour. Working at this radiation level could cause emergency responders who perform mitigation actions to receive doses greater than those in EPA's PAGs (EPA, 1992). This radiation map is the basis for specifying that the SFP makeup must be deployed before the SFP water level reaches the top of the fuel rack in order to credit mitigation success. In addition to radiation, high temperature on the refueling floor is another factor that affects mitigation success. In this study, 140 °F (60 °C) is used as the temperature threshold. The refueling floor reaches 140 °F before the SFP water level is drained to the top of fuel rack only in the OCP 1 and 2 small leak scenarios. In these scenarios, the reactor head is open. Boiling in the reactor cavity significantly increases the temperature on the refueling floor. Figure 99 shows the time history of the refueling floor temperature of the OCP 1 small leak scenarios. The temperature reaches 140 °F in about 13.5 hours. Figure 100 shows the time history of the refueling floor temperature of the OCP 2 small leak scenarios. The temperature reaches 140 °F in about 26 hours. Because of the long available response time and steep temperature increase at the time of 140 °F reached, changing the temperature threshold to a higher temperature does not affect the HRA results. In summary, successful deployment of the mitigation strategy has to be done before the earliest of either the SFP water reaching the top of the fuel rack or the reactor building atmosphere reaching 140 °F. Table 42 shows these available times for the scenarios of interest.	50.54(hh)(2) mitigation should not be credited in design-basis or beyond-design=basis seismic events. The portable equipment is not seismically qualified. Reference NUREG-2161 Table 33. If single SFP accident could result in the interdiction of 9400 square miles of land, what are the projected are the projected surface and ground water consequences? Based on Fukushima NTTF recommendations and Pubic Law 112-074, it seems that credible complications from other SFPs/reactors and their radiological consequences should be evaluated to determine the environmental impacts. The release of millions of curies of radiation would certainly and adversely affect the on-site staff.

8.2.1 Staffing, Procedures, Training, and Response Time <u>This HRA assumes that sufficient plant staff is available for Unit 3 SFP mitigation</u>. In the situation that the hypothetical earthquake causes damage to multiple SSCs, additional events (e.g., fire), and personnel injury, the assumption may not be applicable to some scenarios. To augment staffing, except calling for the off-site plant staff (e.g., to mobilize emergency response facilities), the reference plant can also call for the nearby Delta-Cardiff Volunteer Fire Company to assist in tasks such as SFP mitigation, fire mitigation, and treatment of injured personnel. The fire company could send engines, tankers, a ladder fire truck, an air unit, an ambulance and personnel to the reference plant site. <u>Based upon the above assumptions</u>, this analysis assumes that there is sufficient staff for Unit 3 SFP mitigation. <u>No detailed analysis is performed on the staffing situation for all scenarios</u>. Response Time NEI 06-12, Revision 2, "B.5.b Phase 2 & 3 Submittal Guidance," states that plants should be able to deploy a flexible means of providing SFP makeup (i.e., either 500 gpm of injection or 200 gpm of spray per unit) within 2 hours from the time in which plant personnel diagnose that external SFP makeup is required. This HRA study uses the 2-hour deployment time as the action time for deploying mitigation. The total mitigation time is the sum of delay time, diagnosis time, and action time (discussed in Section 8.3.2.2). **8.2.2 Mitigation Equipment** This HRA study assumes that portable mitigation equipment is available but the installed equipment is <u>not</u> available for Unit 3 SFP mitigation. The portable equipment includes the two portable diesel pumps discussed in this section. The installed equipment includes the fire system and residual heat removal system. <u>If the earthquake causes damage to multiple reactors and SFPs that consequently requires mitigation equipment, there may not be sufficient portable equipment for the Unit 3 SFP mitigation</u>. <u>For the purposes of this study, portable mitigation equipment was assumed to be available</u>. .	If off-site doses or "*doses close to the site did reach levels that can induce early fatalities,"* it stands to reason the early fatalities would occur on-site. On-site/in-plant doses and staff losses may likely prevent mitigative actions and lead to complications from other SFPs/reactors. It is this multi-reactor/SFP accident that should be evaluated. NUREG-2161 extracts are listed for future reference

Draft NUREG-1437 Revision 2 E.3.7 Impact From Accidents at Spent Fuel Pools	Comments
As directed by the Commission in SRM-SECY-12-0025, dated March 9, 2012 (NRC 2012e), after the severe accident at the Fukushima Dai-ichi nuclear power plant, the NRC staff has undertaken regulatory actions that originated from the NTTF recommendations to enhance reactor and SFP safety. On March 12, 2012, the staff issued Order EA-12-051 (NRC 2012a), which requires that licensees install reliable means of remotely monitoring SFP levels to support effective prioritization of event mitigation and recovery actions in the event of a beyond-design-basis external event. In addition, the staff issued Order EA-12-049 (NRC 2012c), which requires that licensees develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities after a beyond-design-basis external event. Upon full implementation of these Orders, SFP safety was anticipated to be significantly increased. The NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design Basis External Events," (NRC 2012c) in March 2012 after the accident at the Fukushima Dai-ichi nuclear plant (NRC 2012f). This Order was effective immediately and directed the nuclear power plants to provide FLEX in response to beyond-design basis external events. The nuclear power plants' Final Integrated Plans provide strategies for maintaining or restoring core cooling, containment cooling, and SFP cooling capabilities for a beyond-design-basis external event. The FLEX strategies and equipment, when coupled with plant procedures, provide a safety benefit for all applicable events, not just the beyond-design-basis events.	See reference comments.
References	**Reference Comments**
EA-12-051, Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation: *. . . the NRC's assessment of new insights from the events at Fukushima Dai-ichi leads the NRC staff to conclude that additional requirements must be imposed on Licensees and CP holders to increase the capability of nuclear*	The NRC withdrew Order EA-12-051 in 2022. It seems inappropriate to reference or credit withdrawn orders. Reference 10 CFR 50.155, *Mitigation of Beyond-Design-Basis Events*. Notwithstanding, EA-12-051 was ordered "*to increase the capability of nuclear power plants to mitigate beyond-design-basis external events";* however, its design requirement of the SFP level

power plants to <u>mitigate beyond-design-basis external events. These additional requirements represent a substantial increase in the protection of public health and safety</u>. *The spent fuel pool level instrumentation shall include the following design features: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion <u>considered in the design of the spent fuel pool structure</u>.* **EA-12-049, Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies For Beyond-Design-Basis External Events**: *Current regulatory requirements and existing plant capabilities allow the NRC to conclude that a sequence of events such as the Fukushima Dai-ichi accident is unlikely to occur ill the U.S, Therefore, continued operation and continued licensing activities do not pose an imminent threat to public health and safety.* *However, NRC's assessment of new insights from the events at Fukushima Dai-ichi leads the staff to conclude that additional requirements must be imposed on Licensees or CP holders to increase the capability of nuclear power plants to mitigate beyond-design-basis external events. These additional requirements are needed to provide adequate protection to public health and safety, as set forth in Section III of this Order.* *The events at Fukushima, however, demonstrate that beyond-design-basis external events may adversely affect: (1) <u>more than one unit at a site with two or more units</u>, and (2) multiple safety functions at each of several units located on the same site.* *<u>The events at Fukushima further highlight the possibility that extreme natural phenomena could challenge the prevention, mitigation, and emergency preparedness</u> defense-in-depth layers.* *Stakeholder input influenced the staff to pursue a more performance-based approach to improve the safety of operating power reactors than envisioned in NTTF Recommendation 4.2, SECY-11-0124, and SECY-11-0137.* *To address the uncertainties associated with beyond-design-basis external events, the NRC is requiring*	instruments is limited to design-basis—the seismic design "*considered in the design of the spent fuel pool structure.*" This is "new and significant information." It extends beyond the Draft NUREG-1437 Revision 2 package. -*- The NRC withdrew Order EA-12-049 in 2022. It seems inappropriate to reference or credit withdrawn orders. Reference 10 CFR 50.155, *Mitigation of Beyond-Design-Basis Events*. Notwithstanding, the "*safety benefits*" of EA-12-049, credited by Draft NUREG-1437 Revision 2, do not apply to severe SFP accidents caused by beyond-design-basis seismic events. As described in NEI 12-06, the (EA-12-049) FLEX strategies assume (1) "*all boundaries of the SFP are intact, including the liner, gates, transfer canals," and (2) "although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool.*" The SFP FLEX strategies assume that all SFP boundaries will remain intact during beyond-design-basis seismic events, regardless of the existing Seismic Category of each SFP boundary. This assumption originates from EPRI Technical Report 1025286. EPRI Technical Report 1025286, Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic states: *The adequacy of the SFP structure is <u>typically</u> assessed by analysis as a Seismic Category I structure. Therefore, the SFP structure is <u>assumed to be seismically adequate for the purposes of this program</u>.* This EPRI assumption is fundamentally wrong and deceptive. It undermines the intent of the Order and negates any "*reasonable assurance of adequate protection of public health and safety in mitigating the consequences of a beyond-design-basis external event.*" Some spent fuel pools, particularly those at old nuclear plants that may request subsequent license renewal, are not Seismic Category I structures. If the SFP structure(s) is not Seismic Category I, neither are the respective SFP gates (components).

additional defense-in-depth measures at licensed nuclear power reactors so that the NRC can continue to have reasonable assurance of adequate protection of public health and safety in mitigating the consequences of a beyond-design-basis external event.

The Commission has determined that ensuring adequate protection of public health and safety requires that power reactor Licensees and CP holders develop, implement and maintain guidance and strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a beyond-design-basis external event. These new requirements provide a greater mitigation capability consistent with the overall defense-in-depth philosophy, and, therefore, greater assurance that the challenges posed by beyond-design-basis external events to power reactors do not pose an undue risk to public health and safety.

NEI 12-06 (Revision 5) Diverse and Flexible Coping Strategies (FLEX) Implementation Guide

This revision of the guide also provides an acceptable method to implement the requirements of Order EA-12-049 while also addressing mitigating strategy approaches for addressing reevaluated flooding and seismic hazard information. The revisions to the guide also align it with the Mitigating Beyond-Design-Basis Events rulemaking.

Cooling and makeup water inventories contained in systems or structures with designs that are robust for the applicable hazard(s)[3] are available.

Fire or other pumps may be available provided they are robust for the applicable hazard(s).

[3]Equipment only needs to be robust for the hazards for which it is relied on for mitigation.

Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design.

Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.

3.2.1.6 SFP Conditions: The initial SFP conditions are:

SFP gates are a weak link in any seismic analysis. Just because a SPF structure is Seismic Category I, does not mean that its gates are Seismic Category I components.

NRC RG 1.29 (Rev. 5), 'Seismic Design Classification for Nuclear Power Plants' states: *The SSCs of a nuclear power plant that are designated as seismic Category I must be designed to withstand the effects of the SSE* [Safe Shutdown Earthquake] *and remain functional. The pertinent quality assurance requirements of Appendix B to 10 CFR Part 50 shall apply to all activities affecting the safety-related functions of seismic Category I SSCs. The following SSCs of a nuclear power plant, including their foundations and supports, should be designated as seismic Category I:*

d. systems[1] or portions thereof (including but not limited to systems such as residual heat removal and auxiliary feedwater) that are needed to (1) shutdown the reactor and maintain it in a safe shutdown condition, (2) remove residual heat (including heat stored within the spent fuel pool), (3) control the release of radioactive material, or (4) mitigate the consequences of an accident;

Several key examples of systems included in items 1.c and 1.d are provided below for reference, but do not represent the complete scope of these items. Determining the complete scope of these items is the applicant's or licensee's responsibility.

--The spent fuel storage pool structure, including the fuel racks.

Footnote 1: The system boundary includes those portions of the system required to accomplish the specified safety function and connected piping up to and including the second isolation valve or outboard containment isolation valve, such that the effects of an earthquake on non-seismic Category I portions of systems may be isolated from seismic Category I portions. This footnote applies wherever the phrase "systems or portions thereof" appears in this guide.

It is important to recognize that Non-Seismic Category I SFP structures were not/are not "*designed to withstand the effects of the SSE* [Safe Shutdown Earthquake] *and remain functional.*" Otherwise stated, Non-Seismic Category I SFP structures (and components) were not designed to remain functional during a design-basis (SSE) earthquake.

1. <u>All boundaries of the SFP are intact, including the liner, gates, transfer canals, etc</u>. *2. Although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool.* *3. SFP cooling system is intact, including attached piping.* *4. SFP heat load assumes the maximum design basis heat load for the site.* ***SECY-11-0124:*** *The staff concluded that additional review is needed to identify specific regulatory actions related to NTTF Recommendation 7 regarding enhanced spent fuel pool makeup capacity and instrumentation for spent fuel pools. For example, <u>the resolution strategy for Recommendation 2.1 may influence the seismic qualification of potential instrumentation for spent fuel pools</u>.* **§ 50.155 Mitigation of <u>Beyond-Design-Basis</u> Events:** *(b) Strategies and guidelines. Each applicant or licensee shall develop, implement, and maintain:* *(1) Mitigation strategies for beyond-design basis external events—Strategies and guidelines to mitigate beyond-design-basis external events from natural phenomena that are developed assuming a loss of all ac power concurrent with either a loss of normal access to the ultimate heat sink or, for passive reactor designs, a loss of normal access to the normal heat sink. These strategies and guidelines must be capable of being implemented site-wide and must include the following:* *(i) Maintaining or restoring core cooling, containment, and spent fuel pool cooling capabilities; and* *(2) Extensive damage mitigation guidelines—Strategies and guidelines to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities under the circumstances associated with loss of large areas of the plant impacted by the event, due to explosions or fire, to include strategies and guidelines in the following areas:* *(i) Firefighting;* *(ii) Operations to mitigate fuel damage; and* *(iii) Actions to minimize radiological release.* *(c) Equipment. (1) The equipment relied on for the mitigation strategies and guidelines required by*	It is unreasonable and fundamentally wrong to assume that Non-Seismic Category I SFP structures (and components)—that are <u>not</u> designed to remain functional during a design-basis earthquake—would remain functional during a beyond-design-basis (worse) earthquake. It is impractical, if not impossible, to physically reinforce Non-Seismic Category I SFP structures (and components), such that they would could satisfy remain functional during a design-basis earthquake. The same is true for Seismic Category I SFP structures (and components)—such that they would remain functional during a beyond-design-basis earthquake. Ultimately, there are no feasible engineering solutions that would protect people and the environment from beyond-design-basis seismic SFP accidents. This is why the nuclear industry concocted the seismically 'robust' contravention. Additional insights may be gained by reviewing RG 1.29 (all revisions). EPRI Technical Report 1025286 also states: *The 50.54(f) Letter requires the seismic walkdown activity to "verify the adequacy of licensee monitoring and maintenance procedures." <u>This will not be done directly by the Seismic Walkdowns and Area Walk-Bys, but it will be indirectly verified based on the findings from these activities, e.g., if degraded conditions are found, the issue, along with the underlying cause, will be evaluated under the plant's CAP</u>.* The NRC approved EPRI Technical Report 1025286, even though it does clearly did not satisfy the intent of NTTF Recommendation 2.3. The NRC's approval of EPRI Technical Report 1025286 appears to circumvent Fukushima NTTF recommendations and Public Law 112-074. **Request For Information Pursuant to Title 10 Of The *Code Of Federal Regulations* 50.54(f) Regarding Recommendations 2.1,2.3, And 9.3, Of The Near-Term Task Force Review Of Insights From The Fukushima Dai-Ichi Accident (March 12, 2012)** states**:**

paragraph (b)(1) of this section must have sufficient capacity and capability to perform the functions required by paragraph (b)(1) of this section.

(2) The equipment relied on for the mitigation strategies and guidelines required by paragraph (b)(1) of this section must be reasonably protected from the effects of natural phenomena that are equivalent in magnitude to the phenomena assumed for developing the design basis of the facility.

(h) Withdrawal of orders and removal of license conditions. (1) On September 9, 2022, Order EA–12–049, "Order Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," and Order EA–12–051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation," are withdrawn for each licensee or construction permit holder that was issued those Orders.

[84 FR 39718, Aug. 9, 2019]

NTTF RECOMMENDATIONS – Enhancing Reactor Safety in the 21st Century (SECY-11-0093)

Current NRC regulations and associated regulatory guidance provide a robust regulatory approach for evaluation of site hazards associated with natural phenomena. However, this framework has evolved over time as new information regarding site hazards and their potential consequences has become available. As a result, the licensing bases, design, and level of protection from natural phenomena differ among the existing operating reactors in the United States, depending on when the plant was constructed and when the plant was licensed for operation.

Over the years, the NRC has initiated several efforts to evaluate risks and potential safety issues resulting from these differences. However, the NRC reviews did not attempt to validate or verify the licensees' IPEEE results or the acceptability of proposed improvements. Further, the IPEEE analyses did not document the potential safety impacts of proposed improvements, and plants were not required to report completion of proposed improvements to the NRC.

The SEP, IPEEE program, USI A-46, and other regulatory initiatives, including licensing actions to address vulnerabilities, have resulted in some plant-specific safety enhancements to address the risk of

The NRC requests that each addressee confirm that they will use the industry developed, NRC-endorsed, seismic walkdown procedures[1] or provide a description of plant-specific walkdown procedures that include the following characteristics:
a. Determination of the seismic walkdown scope and any combined effects
b. Consideration of NUREG-1742, EPRI Report NP-6041, GIP, and common issues and findings discussed in the responses to TI 2515/183
c. Pre-walkdown actions (e.g., data collection, review of drawings and procedures, identification of the plant licensing basis, identification of current seismic protection levels)
d. Identification of SSCs requiring seismic protection and used in the protection of the reactor and spent fuel pool, including the ultimate heat sink (UHS)

Along with an assessment of reactor integrity, the NTIF recommended an evaluation of the spent fuel pool (SFP) integrity. The addressee's evaluation should consider all seismically induced failures that can lead to draining of the SFP. The evaluation should consider SFP walls, liner, penetrations (cooling water supplies or returns, drains), transfer gates and seals, seals and bellows between the SFP, transfer canal, and reactor cavity, sloshing effects (including loss of SFP inventory, wave-induced failures of gates, and subsequent flooding), siphon effects caused by cooling water pipe breaks, and other relevant effects that could lead to a significant loss of inventory of the SFP.

On December 23, 2011, the Consolidated Appropriations Act, Public Law 112-074, was Signed into law. Section 402 of the law also requires a reevaluation of licensees' design basis for external hazards, and expands the scope to include other external events, as described below:

The Nuclear Regulatory Commission shall require reactor licensees to re-evaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licensees as expeditiously as possible, and thereafter when appropriate, as determined by the Commission, and require each licensee to respond to the Commission that the design basis for each reactor meets the requirements of its license, current applicable Commission requirements and guidance for such license. Based upon the evaluations conducted pursuant to this section and other information it deems relevant, the Commission shall require

external events resulting from natural phenomena. However, the staff has not undertaken a comprehensive reestablishment of the design basis for existing plants that would reflect the current state of knowledge or current licensing criteria. As a result, significant differences may exist between plants in the way they protect against design-basis natural phenomena and the safety margin provided. *With regard to seismic hazards, as discussed above, available seismic data and models show increased seismic hazard estimates for some operating nuclear power plant sites. The state of knowledge of seismic hazards within the United States has evolved to the point that it would be appropriate for licensees to reevaluate the designs of existing nuclear power reactors to ensure that SSCs important to safety will withstand a seismic event without loss of capability to perform their intended safety function. As seismic knowledge continues to increase, new seismic hazard data and models will be produced. Thus, the need to evaluate the implications of updated seismic hazards on operating reactors will recur and need to be reevaluated at appropriate intervals.* *Protection from natural phenomena is critical for safe operation of nuclear power plants due to potential common-cause failures and significant contribution to core damage frequency from external events. Failure to adequately protect SSCs important to safety from appropriate design-basis natural phenomena with appropriate safety margins has the potential for common-cause failures and significant consequences as demonstrated at Fukushima.* *The Task Force recommends that the Commission direct the following actions to ensure adequate protection from natural phenomena, consistent with the current state of knowledge and analytical methods. These should be undertaken to prevent fuel damage and to ensure containment and spent fuel pool integrity:* *2.1 Order licensees to reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and if necessary, update the design basis and SSCs important to safety to protect against the updated hazards.* *2.2 Initiate rulemaking to require licensees to confirm seismic hazards and flooding hazards every 10 years and address any new and significant information. If necessary, update the design basis for SSCs important to safety to protect against the updated hazards.*	*licensees to update the design basis for each reactor, if necessary.* *Reevaluation of the design basis with respect to other external events will be requested later as a separate action from this letter. However, licensees are encouraged to consider this when performing the Recommendation 2.3 walkdowns for flooding.* The NRC's approval of EPRI Technical Report 1025286 does not appear to satisfy the intent of NTTF Recommendation 2.3. Because of this NRC approval, the corresponding March 12, 2012 50.54(f) letter was, in part, rendered ineffective. Based on Public Law 112-074, the NRC's approval of EPRI Technical Report 1025286 appears to be an unlawful concession. This concession is "new and significant information." It extends beyond the Draft NUREG-1437 Revision 2 package. Contrary to the Draft NUREG-1437 Revision 2 package, SFP accidents cannot be generically evaluated.

2.3 Order licensees to perform seismic and flood protection walkdowns to identify and address plant-specific vulnerabilities and verify the adequacy of monitoring and maintenance for protection features such as watertight barriers and seals in the interim period until longer term actions are completed to update the design basis for external events.	
The strategies, called EDMGs, implemented to meet the requirements of the 2002 Interim Compensatory Measures Order, subsequent facility-specific license conditions, and ultimately 10 CFR 50.54(hh)(2), did not address external natural hazards (e.g., seismic, flooding tornadoes, hurricanes) or initiating events other than extensive damage to the facilities caused by large fires or explosions. The equipment is not expected to be protected from design-basis or beyond-design-basis external events, such as floods, earthquakes, or high winds.	NEI 06-12, "B.5.b Phase 2 & 3" states: Equipment associated with these strategies is not to be treated as safety-related equipment. As such, it is not subject to any of new special treatment requirements under 10 CFR (e.g., QA, seismic, EQ, etc.). As such, it is imprudent to assume that B.5.b equipment and strategies would successfully mitigate severe SFP accidents induced by beyond-design-basis seismic events.
4.2.4 Spent Fuel Pool Safety *SSCs for spent fuel storage and handling have safety classifications that reflect their importance to safety. SSCs essential to retaining the inventory of spent fuel pool water covering the spent fuel and to maintaining a substantial margin to criticality are typically classified as safety related. Such safety-related SSCs include the spent fuel pool structure and penetrations, the spent fuel storage racks, the neutron-absorbing panels in the racks, and the spent fuel itself. Some fuel handling equipment is also safety related. Because the consequences of many fuel handling events and loss of spent fuel forced cooling events have been evaluated and found to be small, these events are not classified as design-basis events. Consequently, other spent fuel storage and handling equipment and spent fuel pool water inventory makeup and cooling systems may not be classified as safety related. At U.S. reactors, some of the spent fuel pool cooling and makeup systems are powered by safety-grade ac electrical power and some are powered by nonsafety-grade ac electrical power.*	SFP SSCs that are not classified as safety-related are not likely classified as Seismic Category I.
Recommendation 7: The Task Force recommends enhancing spent fuel pool makeup capability and instrumentation for the spent fuel pool. The Task Force recommends that the Commission direct the staff to do the following: *7.1 Order licensees to provide sufficient safety-related instrumentation, able to withstand design-basis natural phenomena, to monitor key spent fuel pool parameters (i.e., water level, temperature, and area radiation levels) from the control room.*	Should not NTTF Recommendation 7.1 state: . . . able to withstand beyond-design-basis natural phenomena?

7.2 Order licensees to provide safety-related ac electrical power for the spent fuel pool makeup system. *7.3 Order licensees to revise their technical specifications to address requirements to have one train of onsite emergency electrical power operable for spent fuel pool makeup and spent fuel pool instrumentation when there is irradiated fuel in the spent fuel pool, regardless of the operational mode of the reactor.* *7.4 Order licensees to have an installed <u>seismically qualified</u> means to spray water into the spent fuel pools, including an easily accessible connection to supply the water (e.g., using a portable pump or pumper truck) at grade outside the building.* *7.5 <u>Initiate rulemaking or licensing activities or both to require the actions related to the spent fuel pool described in detailed recommendations</u> 7.1–7.4.* **REQUEST FOR INFORMATION PURSUANT TO TITLE 10 OF THE *CODE OF FEDERAL REGULATIONS* 50.54(f) REGARDING RECOMMENDATIONS 2.1, 2.3, AND 9.3, OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT:** *Along with an assessment of reactor integrity, the NTIF recommended an evaluation of the spent fuel pool (SFP) integrity. The addressee's evaluation should consider all seismically induced failures that can lead to draining of the SFP. The evaluation should consider SFP walls, liner, penetrations (cooling water supplies or returns, drains), <u>transfer gates and seals, seals and bellows between the SFP, transfer canal, and reactor cavity</u>, sloshing effects (including loss of SFP inventory, wave-induced failures of gates, and subsequent flooding), siphon effects caused by cooling water pipe breaks, and other relevant effects that could lead to a significant loss of inventory of the SFP.* *On December 23, 2011, the Consolidated Appropriations Act, <u>Public Law 112-074</u>, was Signed into law. Section 402 of the law also requires a reevaluation of licensees' design basis for external hazards, and expands the scope to include other external events, as described below:* *The Nuclear Regulatory Commission shall require reactor licensees to re-evaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licensees as expeditiously as possible, and thereafter when appropriate, as*	Contrary to Public Law 112-074, it appears transfer gates and seals, and bellows between the SFP, transfer canal, and reactor cavity were screened out of the 50.54(f) required analyses at many, if not all, nuclear power plants. .

determined by the Commission, and require each licensee to respond to the Commission that the design basis for each reactor meets the requirements of its license, current applicable Commission requirements and guidance for such license. Based upon the evaluations conducted pursuant to this section and other information it deems relevant, the Commission shall require licensees to update the design basis for each reactor, if necessary. *Reevaluation of the design basis with respect to other external events will be requested later as a separate action from this letter. However, licensees are encouraged to consider this when performing the Recommendation 2.3 walkdowns for flooding.* *Footnote 1: For the purpose of this document, <u>plant-specific vulnerabilities</u> are defined as those features important to safety that when subject to an increased demand due to the newly calculated hazard evaluation have not been shown to be capable of performing their intended safety functions.* ***EPRI Technical Report 1025286, Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic, dated June 2012****.* *The 50.54(f) Letter requires the seismic walkdown activity to "verify the adequacy of licensee monitoring and maintenance procedures." <u>This will not be done directly by the Seismic Walkdowns and Area Walk-Bys, but it will be indirectly verified based on the findings from these activities, e.g., if degraded conditions are found, the issue, along with the underlying cause, will be evaluated under the plant's CAP</u>.* *Screen #1 -- <u>Seismic Category I, limits the items to those that have a seismic licensing basis</u>.* *Screen #2 -- Equipment or Systems, considers only those items associated with the spent fuel pool that are appropriate for an equipment walkdown process.* *Screen #3 -- Sample Considerations, represents a process intended to result in SWEL 2 that sufficiently represents a broad population of SFP Seismic Category I equipment and systems to meet the objectives of the NRC 50.54(f) Letter.* *Screen #4 -- Rapid Drain-Down, identifies items that could allow the spent fuel pool (SFP) to drain rapidly. Based on typical designs of spent fuel pools at nuclear power plants, this scope of items would be typically limited to hydraulic lines connected to the*	Reference *EPRI Technical Report 1025286 and see comments above.* .

SFP and the equipment connected to those lines. The adequacy of the SFP structure is <u>typically</u> assessed by analysis as a <u>Seismic Category I</u> structure. <u>Therefore, the SFP structure is assumed to be seismically adequate for the purposes of this program</u>. *The SSCs that should be identified are not Limited to Seismic Category I items, <u>but may be limited</u> to those that could allow rapid drain-down of the SFP. Rapid drain-down is defined as lowering the water level to the top of the fuel assemblies within 72 hours after the earthquake.*	

Draft NUREG-1437 Revision 2 E.3.7 Impact From Accidents at Spent Fuel Pools	**Magnuson Comments**
As a result of the terrorist attacks of September 11, 2001, the NRC issued EA-02-026, "Order for Interim Safeguards and Security Compensatory Measures" (NRC 2002b), referred to as the ICMs Orders, dated February 25, 2002. The ICMs Orders modified then-operating licenses for commercial power reactor facilities to require compliance with specified interim safeguards and security compensatory measures. Section B.5.b of the ICMs Orders requires licensees to adopt mitigation strategies using readily available resources to maintain or restore core cooling, containment, and SFP cooling capabilities to cope with the loss of large areas of the facility due to large fires and explosions from any cause, including beyond-design-basis aircraft impacts. Information about the historical evolution of mitigating measures implemented in response to the ICMs Orders is described in the NRC memorandum dated February 4, 2010 (NRC 2010a).	The NRC withdraw Order EA-02-026. It is imprudent to make any pending or future GEIS conclusions or decisions based on withdrawn NRC Orders. Reference www.morganlewis.com. EA-02-026/B.5.b equipment and strategies do <u>not</u> support Draft NUREG-1437 Revision 2.
References	**Reference Comments**
NEI 06-12, "B.5.b Phase 2 & 3": *Equipment associated with these strategies is not to be treated as safety-related equipment. As such, it is not subject to any of new special treatment requirements under 10 CFR (e.g., QA, <u>seismic</u>, EQ, etc.).*	B.5.b equipment is not designed nor intended to survive a beyond-design-basis seismic event. It is imprudent to assume that B.5.b equipment and strategies would successfully mitigate severe SFP accidents induced by beyond-design-basis seismic events. Reference NUREG-2161.

Draft NUREG-1437 Revision 2 E.3.7 Impact From Accidents at Spent Fuel Pools	Magnuson Comments
E.3.7.2 Other Pathway Impacts *Neither the analyses in NUREG-1738 (NRC 2001) nor those in the NUREG-2161 (NRC 2014a) addressed the impacts with respect to the other pathways (open bodies of water and groundwater). The 1996 LR GEIS estimated these impacts for reactor accidents from full power (internal events only) using the results from plant-specific reactor accident analysis to assess the contamination of open bodies of water and from the Liquid Pathway Generic Study (NUREG-0440; NRC 1978) to assess the contamination of groundwater from basemat melt-through accidents.* *In both cases, the impacts on human health from surface water and groundwater contamination are only a small fraction of impacts from the airborne pathway, except in a few cases where the impacts are comparable. With the impacts from the airborne pathway associated with SFP accidents (as stated in NUREG-1738) being comparable to the impacts from reactor accidents, as stated in NUREG-1150 (NRC 1990), the impacts from SFP-related surface water and groundwater contamination may also be comparable, even though the SFP fuel inventory is several times that of the reactor. This is due to the lower probability of occurrence of SFP accidents, the effects of decay of the fission products on the radionuclide inventory, and the lower energy density of the fuel inventory, which makes basemat melt-through more unlikely.*	Reference NUREG-2161 Table 33. If a single SFP accident could result in the interdiction of 9400 square miles of land, what are the projected are the projected surface and ground water consequences?
References	**Reference Comments**

From: Brian Magnuson
Sent: Tuesday, May 2, 2023 9:40 PM
To: Kevin.Folk@nrc.gov; Jennifer.Davis@nrc.gov
Cc: Karen Gray; Jack Kolar; Gabrielle DeStefano; Brian Magnuson
Subject: Docket ID NRC-2018-0296 – Draft NUREG-1437 Revision 2 - Magnuson Public Comments (Comment Tracking Number lh7-2s93-23io)

RE: Docket ID NRC-2018-0296 – Draft NUREG-1437 Revision 2

Comments by Brian Magnuson
Lead Emergency Management Specialist at Constellation Energy Corporation
Former Reactor Operator, Senior Reactor Operator and, Operations Shift Manager at Quad Cities Nuclear Power Plant

—I submit these comments as a member of the public.

May 2, 2023

Dear NRC Staff:

As stated in my May 1, 2023 comments, I found the referenced studies of Draft NUREG-1437, Revision 2, Section E.3.7 do not support its assumptions and conclusions.

As required by Public Law 112-074, the NRC required[2] each nuclear plant to evaluate plant components, including SFP gates, to ensure they would not fail in the event of a beyond-design-basis earthquake. However, after issuing the March 12, 2012 §50.54(f) letter, the NRC circumvented PL 112-0074 by endorsing EPRI Report 1025286, which allowed nuclear power plants to simply assume that SFP gates will not fail in a beyond-design-basis seismic event.

This assumption (concession) appears unlawful and conflicts with the actual performance of SFP gates under non-seismic conditions (NUREG-1275) and direct observations from the seismic accident at Fukushima published by the National Academy of Sciences[1]:

> *". . . the damage observed in the Unit 3 gates (Figure 2.9) demonstrates a pathway by which a severe accident could compromise spent fuel pool storage safety: drainage of water from a spent fuel pool through a damaged gate breach into an empty volume such as a dry reactor well or fuel transfer canal. A gate breach could drain a spent fuel pool to just above the level of the racks in a matter of hours, and the resulting high radiation fields on the refueling deck could hinder operator response actions."*
>
> *"Assessment of spent fuel pool performance, including gate leakage, is not a new topic for the USNRC. A review of historical data in 1997 (USNRC, 1997c) documented numerous instances of significant accidental drainage of pools in pressurized water reactor and BWR plants due to various failures including gate seals. . . .the report goes on to identify the most prevalent reason for loss of pool inventory was leaking fuel pool gates. <u>Given the potential for gate leakage under normal operations it is not surprising that it is also an issue under severe accident conditions</u>."* [emphasis added]

Given this information, it appears the NRC is ignoring their own research. The NRC has not taken a "hard look" and the environmental impacts of SFP accidents.

Sincerely,
Brian Magnuson
magnuson28@msn.com

[1]*Lessons Learned From the Fukushima Nuclear Accident*
National Academies of Sciences, Engineering, and Medicine.
2016. *Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Plants: Phase 2.* Washington, DC: The National Academies Press. doi: 10.17226/21874.

[2]March 12, 2012 §50.54(f) letter