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DOCKETED  
USNRC

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April 15, 2008 (8:00am)

Office of the Secretary  
Attn: Rulemakings and Adjudications Branch  
U.S. Nuclear Regulatory Commission  
11555 Rockville Pike  
Rockville, MD 20852

OFFICE OF SECRETARY  
RULEMAKINGS AND  
ADJUDICATIONS STAFF

*Subject:* Filing in Diablo Canyon ISFSI licensing case, Docket No. 72-26

Dear Madam/Sir,

On behalf of San Luis Obispo Mothers for Peace, I am enclosing the original and two copies of SAN LUIS OBISPO MOTHERS FOR PEACE'S DETAILED SUMMARY OF FACTS, DATA, AND ARGUMENTS ON WHICH IT INTENDS TO RELY AT ORAL ARGUMENT TO DEMONSTRATE THE INADEQUACY OF THE U.S. NUCLEAR REGULATORY COMMISSION'S FINAL SUPPLEMENT TO THE ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED DIABLO CANYON INDEPENDENT SPENT FUEL STORAGE INSTALLATION TO CONSIDER THE ENVIRONMENTAL IMPACTS OF AN ATTACK ON THE FACILITY (CONTENTION 2).

Please note that the attached Second Declaration of Dr. Gordon R. Thompson (Exhibit 3) is a copy with an electronic signature. Dr. Thompson is currently out of the country, and has sent me his original signed declaration by overnight mail. I will submit it as soon as I receive it.

Sincerely,

  
Diane Curran

Cc: Service list

Template Serv-055

DS-03

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION  
BEFORE THE COMMISSION

In the matter of  
Pacific Gas and Electric Company  
Diablo Canyon Nuclear Power Plant  
Unit Nos. 1 and 2  
Independent Spent Fuel Storage Installation

Docket # 72-26

**SAN LUIS OBISPO MOTHERS FOR PEACE'S DETAILED SUMMARY  
OF FACTS, DATA, AND ARGUMENTS ON WHICH IT INTENDS TO RELY  
AT ORAL ARGUMENT TO DEMONSTRATE THE INADEQUACY OF THE  
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THE ENVIRONMENTAL ASSESSMENT  
FOR THE PROPOSED DIABLO CANYON INDEPENDENT  
SPENT FUEL STORAGE INSTALLATION TO CONSIDER THE  
ENVIRONMENTAL IMPACTS OF AN ATTACK ON THE FACILITY  
(CONTENTION 2)**

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April 14, 2008

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(CONTENTION 2)**

**I. INTRODUCTION**

Pursuant to 10 C.F.R. § 2.1113, San Luis Obispo Mothers for Peace ("SLOMFP") hereby submits a detailed written summary of the facts, data, and arguments ("Summary") on which SLOMFP intends to rely to demonstrate that the Staff of the U.S. Nuclear Regulatory Commission ("NRC" or "Commission") violated the National Environmental Policy Act ("NEPA") by refusing to prepare an environmental impact statement addressing the environmental impacts of an intentional attack on the proposed Diablo Canyon Independent Spent Fuel Storage Installation ("ISFSI" or "spent fuel storage facility"). As set forth below, the NRC Staff's supplement to its

environmental assessment for the licensing of the Diablo Canyon ISFSI<sup>1</sup> is fundamentally inadequate to satisfy NEPA, because it fails to address a very serious and reasonably foreseeable environmental impact of an intentional attack on the Diablo Canyon ISFSI: radiological land contamination and its attendant health, environmental and socioeconomic effects. Moreover, the EA Supplement violates NEPA's requirement for transparency of government decision-making documents, because compelling evidence suggests that the Staff's finding of no significant impact is based on the hidden and unjustified assumption that widespread land contamination does not constitute a significant adverse environmental impact that must be considered in an EIS.

This Summary is supported by the following Exhibits:

- Exhibit 1, Declaration of Dr. Gordon R. Thompson on Behalf of San Luis Obispo Mothers for Peace In Support of Contention 2 Regarding the Construction and Operation of the Diablo Canyon Independent Spent Fuel Storage Installation (June 27, 2007) and attached Curriculum Vitae ("First Thompson Declaration");
- Exhibit 2, Dr. Gordon R. Thompson, *Assessing Risks of Potential Malicious Actions at Commercial Nuclear Facilities: The Case of a Proposed Independent Spent Fuel Storage Installation at the Diablo Canyon Site* (June 27, 2007) ("Report")<sup>2</sup>; and

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<sup>1</sup> Supplement to the Environmental Assessment and Final Finding of No Significant Impact Related to the Construction and Operation of the Diablo Canyon Spent Fuel Storage Installation (August 2007) ("Final EA Supplement"); Supplement to the Environmental Assessment and Final Finding of No Significant Impact Related to the Construction and Operation of the Diablo Canyon Spent Fuel Storage Installation (May 2007) ("Draft EA Supplement") (collectively "EA Supplement").

<sup>2</sup> SLOMFP previously submitted Exhibits 1 and 2 in support of San Luis Obispo Mothers for Peace's Contentions and Request for a Hearing Regarding Diablo Canyon

- Exhibit 3, Second Declaration of Dr. Gordon R. Thompson on Behalf of San Luis Obispo Mothers for Peace In Support of Contention 2 Regarding the Construction and Operation of the Diablo Canyon Independent Spent Fuel Storage Installation (June 27, 2007) and attached Curriculum Vitae (“First Thompson Declaration”). Copies of the Exhibits are attached to this Summary.

Based on the record of this proceeding, including the Draft and Final EA Supplements, documents disclosed by the NRC Staff during discovery, and Dr. Thompson’s Report and Second Declaration, there is no dispute that the EA Supplement for the Diablo Canyon ISFSI fails to address the environmental impacts of credible attack scenarios that could have significant environmental impacts on the human environment, including widespread radiological land contamination and its attendant adverse effects on human health and welfare, the environment, and the economy. The NRC Staff has provided no plausible justification for its failure to address these significant impacts in the EA Supplement, and indeed appears to have intentionally excluded contamination-related impacts from consideration based on a secret and arbitrary agency policy of disregarding any impacts of an attack other than immediate fatalities.

Accordingly, as provided by 10 C.F.R. § 2.1115(a)(2), the Commission should rule that there is no unresolved dispute of law or fact regarding Contention 2, and that SLOMFP should prevail on the claims raised in the contention. Therefore PG&E’s application for a license for the Diablo Canyon ISFSI should be denied unless and until the Staff prepares an EIS that fully addresses the environmental impacts of an attack on

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Environmental Assessment Supplement (June 28, 2007; corrected June 29, 2007) (“SLOMFP Hearing Request”).

the Diablo Canyon ISFSI, as well as a range of reasonable alternatives for mitigating or avoiding those impacts.

## II. STATEMENT OF THE CASE

This proceeding marks the second time that SLOMFP has sought compliance by the NRC with NEPA with respect to the consideration of the environmental impacts of an intentional attack on the proposed Diablo Canyon ISFSI. After Pacific Gas and Electric Company (“PG&E”) filed its application for a license for the ISFSI in late 2001, SLOMFP requested the NRC to grant a hearing on whether, in light of recent attacks on U.S. facilities, including the attacks of September 11, 2001, the NRC should address the impacts of an attack on the proposed Diablo Canyon facility in an environmental impact statement (“EIS”). The Commission categorically refused to consider SLOMFP’s request in *Pacific Gas and Electric Co. (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation)*, CLI-03-01, 57 NRC 1 (2003). In *San Luis Obispo Mothers for Peace*, 449 F.3d 1016 (9th Cir. 2006), cert. denied, 127 S.Ct. 1124 (2007), the United States Court of Appeals for the Ninth Circuit reversed the Commission’s decision and remanded the case for further proceedings.

On remand, the NRC Commissioners ordered the NRC Staff to prepare a preliminary analysis, known as an environmental assessment (“EA”), to evaluate whether the NRC should prepare a full-blown EIS to evaluate the environmental impacts of an intentional attack on the proposed facility. *Pacific Gas and Electric Co. (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation)*, CLI-07-11, 65 NRC 148 (2007). In response to the Commission’s Order, the NRC Staff issued the Draft EA

Supplement, declaring that an attack on the proposed facility would have no significant impact on the human environment.

In contentions filed June 28, 2008, SLOMFP challenged the Draft EA Supplement for its failure, among other things, to address the dominant impact of spent fuel storage attacks: land contamination, a very serious impact that can render uninhabitable a large land area, causing significant health, economic and social impacts. SLOMFP also charged that the Draft EA Supplement defined adverse impacts only in terms of early deaths, and therefore appeared to rely on the hidden assumption that any impacts other than early fatalities should be ruled out as unworthy of consideration. SLOMFP Hearing Request, Contention 2. SLOMFP also charged that the NRC Staff had violated NEPA by failing to identify the reference documents on which it had relied in preparing the Draft EA Supplement. *Id.*, Contention 1.

Since then, the Staff has provided additional information in the form of a Final EA Supplement, a list of reference documents, disclosure of portions of the redacted reference documents, and responses to SLOMFP's discovery questions. Unfortunately, this additional information does not demonstrate that the Staff has, in fact, considered the environmental effects of credible attack scenarios that could cause significant offsite radiological contamination. Indeed, the documents provide compelling evidence that the Staff followed an established policy of screening out land contamination and other non-fatal environmental effects as unworthy of consideration. Whether or not the Staff did indeed apply such a policy, however, the evidence shows that the Staff's finding of no significant is irrational and unsupported, and therefore must be rejected as inadequate to satisfy NEPA. Because PG&E's application is not supported by an adequate

environmental analysis, it must also be rejected, until such time as the NRC Staff may prepare an EIS that adequately addresses the environmental impacts of an attack on the Diablo Canyon spent fuel storage facility.

### **III. STATUTORY AND REGULATORY FRAMEWORK**

#### **A. Requirements of NEPA**

NEPA is the “basic charter for the protection of the environment.” 40 C.F.R. § 1500.1(1). Its fundamental purpose is to “help public officials make decisions that are based on understanding of environmental consequences, and take decisions that protect, restore, and enhance the environment.” *Id.* NEPA requires federal agencies to examine the environmental consequences of their actions *before* taking those actions, in order to ensure “that important effects will not be overlooked or underestimated only to be discovered after resources have been committed or the die otherwise cast.” *Robertson v. Methow Valley Citizen Council*, 490 U.S. 332, 349 (1989).

#### **1. Environmental impact statement**

The primary method by which NEPA ensures that its mandate is met is the “action-forcing” requirement that a “detailed statement,” known as an Environmental Impact Statement (“EIS”), be prepared before a federal agency takes any major action which may significantly affect the quality of the human environment. 42 U.S.C. § 4332(2)(C); 40 C.F.R. § 1502.1.<sup>3</sup> The NRC’s implementing regulations at 10 C.F.R. §

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<sup>3</sup> 40 C.F.R. § 1502.1 is a regulation of the President’s Council on Environmental Quality (“CEQ”) for the implementation of NEPA. Although the NRC also has its own NEPA regulations, the CEQ regulations are binding on the NRC unless compliance would “be inconsistent with statutory requirements.” Executive Order 11991, 3 C.F.R. 124 (1978). *See also Baltimore Gas and Electric Co. v. Natural Resources Defense Council*, 462 U.S. 87 (1983); *Andrus v. Sierra Club*, 442 U.S. 347 (1979); NRC Final Rule, Environmental

51.20(a) also require the NRC to prepare an EIS for any licensing or regulatory action which “is a major federal action significantly affecting the quality of the human environment.”

As required by NEPA and its implementing regulations, an EIS must describe, among other things, (1) the “environmental impact” of the proposed action, (2) any “adverse environmental effects which cannot be avoided should the proposal be implemented,” (3) any “alternatives to the proposed action,” and (4) any “irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. . . .” 42 U.S.C. § 4332(C). The EIS must be circulated in draft for comment by the public and other affected agencies, in order to assure that relevant environmental information will “be made available to the larger audience that may also play a role in both the decisionmaking process and the implementation” of a proposed decision. *Robertson*, 490 U.S. at 349.

An EIS must be searching and rigorous, providing a “hard look” at the environmental consequences of the agency’s proposed action. *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 374 (1989). Information about environmental impacts must be subject to a “careful scientific analysis.” *Id.* at 385. *See also* 40 C.F.R. § 1502.24 (“Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements”); 10 C.F.R. § 51.71(d) (draft EIS “considers and weighs the environmental effects of the proposed action”).

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Protection Regulations for Domestic Licensing and Related Regulator Functions and Related Conforming Amendments, 49 Fed. Reg. 9,352 (March 12, 1984).

In making environmental decisions, an agency may not rely on hidden or misleading assumptions. As the U.S. Court of Appeals for the Fifth Circuit held in *South Louisiana Env'tl. Council v. Sand*, 629 F.2d 1005, 1011-12 (5th Cir. 1980), an agency's reliance on misleading assumptions violates NEPA by "impairing the agency's consideration of the adverse environmental effects of a proposed project." *See also Johnston v. Davis*, 698 F.2d 1088, 1094 (10th Cir. 1983) (holding that misleading or unqualified statements that do not represent a realistic assessment of environmental impacts violate NEPA); *Hughes Watershed Conservancy v. Glickman*, 81 F.3d 437, 446 (4th Cir. 1999) (rejecting an EIS that contained misleading projections of a proposed project's economic benefits); *Calvert Cliffs Coordinating Committee v. AEC*, 449 F.2d 1109, 1113 (D.C. Cir. 1971) (an environmental impact statement must be "detailed" and the analysis carried out "fully and in good faith.")

Environmental impacts that must be considered in an EIS include those which are "reasonably foreseeable" and have "catastrophic consequences, even if their probability of occurrence is low." 40 C.F.R. § 1502.22(b)(1). However, environmental impacts that are "remote and speculative" need not be considered. *Limerick Ecology Action v. NRC*, 869 F.2d 719, 745 (3<sup>rd</sup> Cir. 1989), citing *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.*, 435 U.S. 519, 551 (1978). The fact that the likelihood of an impact may not be easily quantifiable is not an excuse for failing to address it in an EIS. NRC regulations require that: "[t]o the extent that there are important qualitative considerations or factors that cannot be quantified, these considerations or factors will be discussed in qualitative terms." 10 C.F.R. § 51.71.

In *San Luis Obispo Mothers for Peace*, the U.S. Court of Appeals for the Ninth Circuit rejected, as irrational, a previous NRC policy of refusing to consider the environmental impacts of intentional attacks on nuclear facilities on the asserted ground that they are remote and speculative. Therefore, the NRC has reversed its policy in this case and ordered the preparation of an EA to consider whether the impacts of an attack on the Diablo Canyon ISFSI should be addressed in an EIS. *Pacific Gas and Electric Co.* (Diablo Canyon ISFSI), CLI-07-011, 65 NRC 148 (2007), citing *San Luis Obispo Mothers for Peace*.<sup>4</sup>

## 2. Environmental Assessment

NEPA requires that, in actions involving substantial undertakings, such as the instant proposal to store spent nuclear power plant fuel at a new facility on the Diablo Canyon site, an agency may not dispense with an EIS unless and until it has prepared an EA that evaluates whether an EIS is required, taking into account all relevant factors. *LaFlamme v. FERC*, 852 F.2d 389, 399 (9th Cir. 1988) (hydroelectric power plant license suspended for failure to prepare an EA). Like an EIS, an EA must take a “hard look” at the potential environmental consequences of the action. *See also Maryland National Park and Planning Commission v. U.S. Postal Service*, 487 F.2d 1029, 1040 (D.C. Cir. 1973); *Foundation on Economic Trends v. Heckler*, 756 F.2d 143, 154 (D.C. Cir. 1985) (EA must “attempt to evaluate seriously the risk[s]” posed by proposed action.) As the D.C. Circuit of the U.S. Court of Appeals noted in *Foundation on Economic Trends*, “one of the specific criteria for determining whether an EIS is necessary is ‘[t]he degree to

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<sup>4</sup> *But see Amergen Energy Company, L.L.C.* (Oyster Creek Nuclear Generating Station), CLI-07-08, 65 NRC 124 (2007) (majority opinion declaring that the NRC will comply

which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.” 756 F.2d at 155, citing 40 C.F.R. § 1508.27(b)(5). Thus, in *Blue Mountains Biodiversity Project v. Blackwood*, 161 F.3d 1208, 1213 (9th Cir. 1998), the Court found that “[a] project may have significant environmental impacts where its effects are ‘highly uncertain or involve unique or unknown risks.’” *See also Morgan v. Walter*, 728 F.Supp. 1483, 1489 (D. Id. 1989).

### **B. Procedural Standards for Subpart K Proceedings**

The Commission has chosen to adjudicate SLOMFP’s Contention 2 under Subpart K of its procedural regulations in 10 C.F.R. Part 2. Subpart K is an “abbreviated hearing process” that “derives from the NWSA [Nuclear Waste Policy Act], where Congress called on the Commission to ‘encourage and expedite’ onsite spent fuel storage.” *Carolina Power & Light Co. (Shearon Harris Nuclear Power Plant)*, CLI-01-11, 53 NRC 370 (2001), citing 42 U.S.C. § 10151(a)(2). Following a period of discovery, the parties must submit legal arguments and factual evidence in the form of testimony or declarations. 10 C.F.R. § 2.1113. After holding an oral argument, the NRC must:

- (1) Designate any disputed issues of fact, together with any remaining issues of law, for resolution in an adjudicatory hearing; and
- (2) Dispose of any issues of law or fact not designated for resolution in an adjudicatory hearing.

10 C.F.R. § 2.1115(a). The regulations forbid designation of an issue for resolution in a hearing unless the presiding officer determines that:

- (1) There is a genuine and substantial dispute of fact which can only be resolved with sufficient accuracy by the introduction of evidence in an adjudicatory hearing; and
- (2) The decision of the Commission is likely to depend in whole or in part on the resolution of that dispute.

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with *San Luis Obispo Mothers for Peace* only in the Ninth Circuit).

10 C.F.R. § 2.1115(b).

To the extent that an intervenor seeks disposition of an environmental against the NRC Staff under 10 C.F.R. § 2.1115(a)(2), the NRC Staff bears the burden of proof. *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), LBP-01-09, 53 NRC 239, 249 (2001), affirmed, CLI-01-11, 53 NRC 370 (2001). *See also Louisiana Energy Services* (Claiborne Enrichment Center), LBP-96-25, 44 NRC 331, 338 (1996) (Staff has burden of proof in defending its own environmental studies). To the extent that an intervenor argues, under 10 C.F.R. § 2.1115(a)(1), that there is a dispute regarding any issue of fact or law that must be resolved in a hearing, the intervenor bears the burden of making that showing. *Harris*, LBP-01-09, 53 NRC at 249.

#### IV. ADMITTED SLOMFP CONTENTION 2

The subject of this Subpart K proceeding is SLOMFP's Contention 2, which is supported by the Thompson Report. In relevant part, SLOMFP Contention 2 states as follows:

The EA Supplement fails to satisfy NEPA because the NRC's decision not to prepare an EIS is based on hidden and unjustified assumptions.

**Basis:** As the U.S. Court of Appeals for the Fifth Circuit held in *South Louisiana Env'tl. Council v. Sand*, 629 F.2d 1005, 1011-12 (5<sup>th</sup> Cir. 1980), an agency's reliance on misleading assumptions violates NEPA by "impairing the agency's consideration of the adverse environmental effects of a proposed project." *See also Johnston v. Davis*, 698 F.2d 1088, 1094 (10<sup>th</sup> Cir. 1983) (holding that misleading or unqualified statements that do not represent a realistic assessment of environmental impacts violate NEPA); *Hughes Watershed Conservancy v. Glickman*, 81 F.3d 437, 446 (4<sup>th</sup> Cir. 1999) (rejecting an EIS that contained misleading projections of a proposed project's economic benefits).

Here, the EA Supplement violates NEPA by relying on hidden and unjustified assumptions. For instance, the EA Supplement appears to assume that the environmental impacts of an attack on a spent fuel storage cask would be

insignificant if they do not result in early fatalities. This assumption is not completely clear, but can be inferred from the document's discussion of consequences. In considering the consequences of potential releases of radioactive material, the NRC has employed only one indicator, namely "the potential for early fatalities." EA at 6. The Staff thus appears to have used early fatalities as a criterion to screen out consideration of any threat scenarios that cause impacts other than early fatalities.

To exclude consequences other than early fatalities is absurd. The adverse health effects of a successful attack on the Diablo Canyon ISFSI would include increased cancers and illnesses (Thompson Report at 17, 35), which indisputably constitute significant adverse environmental impacts that are routinely considered in NRC's EISs.<sup>4</sup> Moreover, as discussed in Dr. Thompson's report, land contamination -- the dominant impact of spent-fuel-storage conventional accidents or attacks -- is a very serious impact that can render uninhabitable a large land area, causing significant economic and social impacts. *Id.*

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<sup>4</sup> See, e.g., NUREG-1767, Vol. 1, Environmental Impact Statement on the Construction and Operation of a Proposed Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina, Table 4.14 (2005), which provides an estimate of "latent" cancer fatalities as a result of facility accidents.

SLOMFP Contentions at 10-12.

In CLI-08-01, the Commission admitted Contention 2 with respect to the portion of the contention quoted above, holding that:

The Staff correctly points out that the assessment mentions early fatalities only in the context of the consideration of the need for additional security measures and that the assessment goes on to provide dose estimates and other findings in support of its determination. However, SLOMFP stresses that while the environmental assessment emphasizes low potential radiation doses to humans from a hypothetical terrorist attack, it appears to be silent on the possibility of land contamination -- a possibility SLOMFP's expert considers significant and serious. We cannot say, under the standards applicable at this stage, that SLOMFP's concern that the environmental assessment ignores environmental effects on the surrounding land is unworthy of further inquiry. Nor do we reject at the threshold SLOMFP's request to litigate its claim that the NRC Staff has not considered non-fatal health effects (e.g., latent cancers) from a hypothetical terrorist attack. The environmental assessment appears to be silent on that point as well. The Staff may be able to easily explain how much issues were addressed by reference to source documents, including the 2003 environmental assessment, or how such issues are bounded and were implicitly addressed by the very low dose estimates

and other considerations, but we believe further inquiry is appropriate.

CLI-08-01, slip op. at 20-21 (January 15, 2008).

**V. FACTS AND ARGUMENTS ON WHICH SLOMFP INTENDS TO RELY AT ORAL ARGUMENT**

**A. Dr. Thompson is Highly Qualified to Testify Regarding Contention 2.**

SLOFMP's Summary is supported by a detailed expert declaration by Dr. Gordon Thompson (Second Thompson Declaration, Exhibit 3) and by Dr. Thompson's detailed expert report that SLOMFP submitted in support of Contention 2 (Exhibit 2). Dr. Thompson is a highly qualified expert with respect to the technical issues of nuclear facility vulnerability and risk analysis that are in dispute in this proceeding. He is qualified by "knowledge, skill, experience, training, or education" to render an expert opinion on the adequacy of the NRC Staff's analysis of the environmental impacts of an intentional attack on the proposed Diablo Canyon spent fuel storage facility, and his expert opinion will "assist the trier of fact to understand the evidence" and to determine the facts in issue. *See* Federal Rule of Evidence 702, which was held applicable to NRC proceedings in *Duke Power Co. (William B. McGuire Nuclear Station, Units 1 and 2)*, ALAB-669, 15 NRC 453, 475 (1972).

Dr. Thompson's high level of expert qualifications are set forth in the declaration he submitted in support of SLOMFP's contentions, and in the curriculum vitae that is attached to that declaration. *See* Exhibit 1, First Thompson Declaration. As stated there, his undergraduate and graduate work provided him with a rigorous education in the methodologies and disciplines of science, mathematics, and engineering. First Thompson Declaration, par. 2. He received an undergraduate education in science and mechanical

engineering at the University of New South Wales, in Australia. In 1973 he received a Doctor of Philosophy degree in physics from Oxford University, for analyses of plasmas undergoing thermonuclear fusion. During Dr. Thompson's graduate studies he was associated with the fusion research program of the UK Atomic Energy Authority. *Id.*, par. 2.

Since 1977, a significant part of Dr. Thompson's work has consisted of technical analyses of safety, security and environmental issues related to nuclear facilities. These analyses have been sponsored by a variety of nongovernmental organizations and local, state and national governments, predominantly in North America and Western Europe. Drawing upon these analyses, he has provided expert testimony in legal and regulatory proceedings, and has served on committees advising US government agencies. *Id.*, par. 3.

Dr. Thompson has conducted, directed, and/or participated in a number of studies that evaluated aspects of the design and operation of nuclear facilities with respect to severe accident probabilities and consequences. These include generic studies and studies of individual facilities. For instance, with respect to generic studies on the potential for severe accidents at nuclear power plants, he was co-investigator in a study by the Union of Concerned Scientists on the "source term" issue -- the potential for release of radioactive material to the environment. In addition, he was one of a team of four scientists who prepared, for Greenpeace International, a comprehensive critique of the state of the art of probabilistic risk assessment ("PRA") for nuclear power plants. That report noted that acts of malice, such as sabotage and acts of war, are not considered in PRAs, despite a history of malicious acts at many nuclear facilities. In addition, Dr.

Thompson conducted analysis on the relevance of PRA to emergency response planning, as part of a study on emergency planning for nuclear power plant accidents. All of these studies required Dr. Thompson to be highly familiar with the design and operation of nuclear power plants, as well as the characteristics of probabilistic risk assessment. *Id.*, par. 4.

Dr. Thompson has also done considerable work on the risks posed by individual nuclear facilities. In addition to performing the studies described elsewhere in this declaration, he has studied the risks posed by the Seabrook, Pilgrim, Vermont Yankee and Three Mile Island plants (USA), the Darlington and Pickering stations (Canada), the Sizewell B station (United Kingdom (“UK”)) and the Dukovany plant (Czech Republic). All of these studies required him to become familiar with the relevant details of the design and operation of the facilities involved. *Id.*, par. 5.

To a significant degree, Dr. Thompson’s work has been accepted or adopted by relevant governmental agencies. During the period 1978-1979, for example, he served on an international review group commissioned by the government of Lower Saxony (a state in Germany) to evaluate a proposal for a nuclear fuel cycle center at Gorleben. He led the subgroup that examined accident risks and identified alternative options with lower risk. One of the risk issues that he identified and analyzed was the potential for self-sustaining, exothermic oxidation reactions of fuel cladding in a high-density spent fuel pool if water is lost from the pool, *i.e.*, a “pool fire.” In examining the potential for a pool fire, Dr. Thompson identified partial loss of water as a more severe condition than total loss of water. He identified a variety of events that could cause a loss of water from a pool, including aircraft crash, sabotage, terrorism and acts of war. He also identified and

described alternative fuel storage options with lower risk; these lower-risk options included design features such as spatial separation, natural cooling and underground vaults. The Lower Saxony government accepted Dr. Thompson's findings about the risk of a pool fire, and ruled in May 1979 that high-density pool storage of spent fuel was not an acceptable option at Gorleben. As a direct result, policy throughout Germany has been to use dry storage in casks, rather than high-density pool storage, for away-from-reactor storage of spent fuel. *Id.*, par. 6.

Dr. Thompson's work has also influenced decision making by safety officials in the U.S. Department of Energy ("DOE"). During the period 1986-1991, he was commissioned by environmental groups to assess the safety of the military production reactors at the Savannah River Site, and to identify and assess alternative options for the production of tritium for the US nuclear arsenal. Initially, much of the relevant information was classified or otherwise inaccessible to the public. Nevertheless, Dr. Thompson addressed safety issues through analyses that were recognized as accurate by nuclear safety officials at DOE. He eventually concluded that the Savannah River reactors could not meet the safety objectives set for them by DOE. DOE subsequently reached the same conclusion, and scrapped the reactors. The current national policy for tritium production is to employ commercial reactors, an option that Dr. Thompson had concluded was technically attractive but problematic from the perspective of nuclear weapons proliferation. *Id.*, par. 7.

In 1977, and again during the period 1996-2000, Dr. Thompson examined the safety of nuclear fuel reprocessing and liquid high-level radioactive waste management facilities at the Sellafield site in the UK. His investigation during the latter period was

supported by consortia of local governments in Ireland and the UK, and he presented his interim findings at briefings in the UK and Irish parliaments in 1998. In the course of that study, Dr. Thompson identified safety issues that were not addressed in any publicly available literature about the Sellafield site. As a direct result of Dr. Thompson's investigation, the UK Nuclear Installations Inspectorate ("NII") required the operator of the Sellafield site -- British Nuclear Fuels ("BNFL") -- to conduct extensive safety analyses. These analyses confirmed the significance of the safety issues that he had identified, and in January 2001 the NII established a legally binding schedule for reduction of the inventory of liquid high-level radioactive waste at Sellafield. The NII took this action in recognition of the grave offsite consequences of a release to the environment from the tanks in which liquid high-level waste is stored. Dr. Thompson had identified a variety of events that could cause such a release, including acts of malice or insanity. *Id.*, par. 8.

In May 2000, Dr. Thompson completed a study for Greenpeace International on the hazard potential of the La Hague site in France. Nuclear fuel reprocessing and related activities are conducted at this site. The operator of the site -- COGEMA -- was authorized to store 14,000 tonnes of spent fuel in high-density pools at La Hague, and proposed to increase the capacity of these pools to 17,600 tonnes. Dr. Thompson's study described the potential for a pool fire at La Hague, and identified events -- including acts of malice or insanity -- that could lead to a pool fire. One of the findings of his study was that neither COGEMA nor the French government had a thorough understanding of La Hague's hazard potential, including the potential for a pool fire. Subsequent to the attacks of September 11, 2001 in New York City and Washington, D.C., media exposure brought

La Hague's hazard potential to the attention of the French government. During October 2001 the French government deployed anti-aircraft missiles at La Hague. *Id.*, par. 9.

As discussed above, during the period 1978-1979, Dr. Thompson determined that partial loss of water from a high-density spent fuel pool is a more severe condition than total loss of water.<sup>5</sup> The NRC Staff failed, for more than two decades, to understand this point. An illustration of the Staff's lack of understanding was provided by its statements during a license amendment proceeding for the proposed expansion of spent fuel pool storage capacity at the Harris nuclear power plant, in which Dr. Thompson served as an expert witness for the Intervenor, Orange County, North Carolina. In filings during March and April 2000, the Staff repeatedly disparaged Dr. Thompson's statements that comparatively old fuel can ignite. A few months later, however, the Staff adopted Dr. Thompson's position. In a report dated October 2000, but not published until January 2001, the Staff recognized that the flow of air to exposed fuel assemblies could be blocked by the presence of collapsed structures -- which might be attributable, for example, to a cask drop or an earthquake -- or by the presence of residual water. The Staff analyzed the heat transfer implications of flow blockage and concluded:

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

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<sup>5</sup> As discussed in par. 10 of the Firsts Thompson Declaration, this is because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies. During any scenario for loss of water from a spent fuel pool, there will be a period of time during which residual water is present. As a result, comparatively old fuel -- potentially including fuel aged 10 or more years after discharge from a reactor -- can ignite if water is lost from a high-density spent fuel pool.

*Id.*, par. 10.

On numerous occasions, Dr. Thompson has drawn attention in his writings and oral presentations to the vulnerability of nuclear facilities to acts of malice or insanity. He has pointed out that PRAs do not address acts of malice or insanity, with the result that a PRA can, at best, provide a lower bound to the probability of a release of radioactive material. In 1996, he wrote a generic report on war and terrorism as risk factors for nuclear power plants. Among other findings, this report noted that an act of war or terrorism at a nuclear power plant might have as its primary target the spent fuel stored at the plant, rather than the reactor. The report concluded with a statement that:

Public debate about the future operation of existing nuclear power plants, and the construction of new plants, should be broadened to encompass the possible involvement of nuclear plants in war or terrorism.

*Id.*, par. 11.

Dr. Thompson is familiar with the License Application, Safety Analysis Report, and Environmental Report for PG&E's proposed ISFSI. He is also familiar with the NRC's Draft and Final EA Supplements. In support of Contention 2, Dr. Thompson prepared a report that includes an analysis of the deficiencies in the Diablo EA Supplement's evaluation of the environmental impacts of intentional attacks on the proposed Diablo Canyon spent fuel storage facility. *See Exhibit 2.*

Accordingly, Dr. Thompson is highly qualified to testify in this proceeding, by virtue of his training, his many years of experience in the analysis of safety, risk, and environmental issues affecting nuclear facilities, and his familiarity with the facts of this case.

**B. The NRC Violated NEPA by Failing to Address, in an EIS, the Significant Environmental Impacts of an Attack on the Diablo Canyon ISFSI in the Form of Widespread Land Contamination and its Associated Effects.**

As discussed above in Section III, the NRC Staff was required by NEPA to take a “hard look,” in its EA Supplement, at the environmental impacts of an intentional attack on the Diablo Canyon spent fuel storage facility. The EA Supplement falls far short of this statutory requirement. While the NRC Staff claims, in the EA Supplement, to address the environmental impacts of “plausible threat scenarios” (Final EA Supplement at 6 and 7), in fact the Staff completely ignores the impacts of a range of credible attacks that could cause significant radioactive land contamination, leading to severe adverse effects on human health and welfare, the environment, and the economy. Moreover, the record contains compelling evidence that in ignoring radioactive land contamination as an environmental impact, the Staff was following a secret NRC policy of screening out non-fatal impacts as unworthy of consideration in NRC security and environmental analyses. In any event, regardless of what ground the NRC Staff relied on to disregard the significant adverse impacts of land contamination and related effects resulting from an attack on the Diablo Canyon ISFSI, the EA Supplement’s failure to consider these credible and significant impacts renders it fatally defective under NEPA.

**1. The EA Supplement ignores credible and significant impacts of an attack on the Diablo Canyon ISFSI.**

As demonstrated in Section V of Dr. Thompson’s Second Declaration, the Staff’s finding of no significant impact is contradicted by information that can be gleaned from publicly available documents, applying knowledge of engineering and related disciplines. This information shows that it is reasonably foreseeable that an attack-induced

atmospheric release of radiological material from a spent fuel storage module of the type that would be used at the Diablo Canyon ISFSI could cause a significant degree of land contamination. A competent, sub-national group seeking to create offsite radiological impacts by attacking a storage module at the Diablo Canyon ISFSI would probably seek to penetrate the wall of the multi-purpose canister (“MPC”) and ignite the zirconium fuel cladding, with the intent of initiating a fire that would release radioactive material to the environment. Thompson Report at 43. Such an attack could be accomplished by various means. Thompson Report at 33-37.

A credible attack on the Diablo Canyon ISFSI could release to the atmosphere tens of percent of the inventory of cesium-137 in affected spent-fuel modules. Second Thompson Declaration, par. II-3. Deposition of cesium-137 from that release could render thousands of square kilometers of land uninhabitable. Sequelae would include contamination of food and water, cancer and other adverse health effects that would be manifested years after the release, relocation of populations, abandonment of real estate, and various economic and social impacts. Economic losses could amount to tens of billions of dollars. *Id.* See also Thompson Report at 15-17, 37.

**2. The EA Supplement relies on a hidden and irrational assumption that non-fatal impacts need not be considered.**

The EA Supplement provides only one direct indicator of an adverse outcome of an attack on an ISFSI: the potential for early fatalities. Second Thompson Declaration, par. III-1. Thus, SLOMFP has inferred that the NRC Staff, in preparing the EA Supplement, assumed that the environmental impacts of an attack on an ISFSI would be insignificant if the attack does not result in early fatalities. *Id.*, Section III. The policy of

screening out attacks with non-fatal consequences was set forth in a 2004 memorandum from the NRC Staff to the Commissioners, SECY-04-0222, Memorandum from Luis A. Reyes to the Commissioners re: Decision-making Framework for Materials and Research and Test Reactor Vulnerability Assessments (November 24, 2004) (“SECY-04-0222”) and approved by the NRC Commissioners in SRM-SECY-04-0222, Staff Requirements Memorandum re: Decision-making Framework for Materials and Research and Test Reactor Vulnerability Assessments (January 15, 2005) (“SRM-SECY-04-0222”).

While the title of SECY-04-0222 indicates that the policy applies only to source materials facilities and research and test reactors, the NRC Staff has listed both SECY-04-0222 and SRM-SECY-04-0222 as reference documents in a November 2007 addendum to the Final EA Supplement, thus indicating the Staff has applied the policy to the Diablo Canyon ISFSI.<sup>6</sup> A subsequent NRC memorandum, also listed as a reference document in the November 2007 Addendum, revealed that the Staff had “performed framework assessments” for spent fuel storage casks and transportation packages “in accordance with SRM-SECY-04-0222.” Second Thompson Declaration, par. III-4, quoting Memorandum by Jack R. Strosnider, Office of Nuclear Material Safety and Safeguards, to Roy P. Zimmerman, Office of Nuclear Security and Incident Response, re: Framework for Assessment of Spent fuel Storage Casks and Transportation Packages and

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<sup>6</sup> Notably, while the Final EA Supplement was published in August of 2007, these reference documents were not identified until November. Memorandum from Robert A. Nelson, Chief, Licensing Branch, Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards, to Michael T. Lesar, Chief, Rulemaking, Directives, and Editing Branch, Division of Administrative Services, Office of Administration re: Notice of Issuance of Addendum to the Supplement to the Environmental Assessment for the Diablo Canyon Independent Spent Fuel Storage Installation (November 7, 2007) (“November 2007 Addendum”).

Radioactive Material Transportation Packages (December 9, 2005) (“Strosnider Memorandum”). The Strosnider Memorandum is also listed as a reference document in the November 2007 Addendum.

SECY-04-0222, SRM-SECY-04-0222, and the Strosnider Memorandum were unavailable publicly until the Staff released redacted versions in conjunction with the Staff’s publication, on February 13, 2008, of a Vaughn Index. Thus, they appear to constitute “secret law” whose suppression was unlawful under the Freedom of Information Act (“FOIA”). *Hardy v. Bureau of Alcohol, Tobacco & Firearms*, 631 F.2d 653, 657 (9th Cir. 1980). *See also* Memorandum from Stephen D. Dingbaum, Assistant Inspector General for Audits, to Luis A. Reyes, Executive Director for Operations, re: Audit of NRC’s Process for Release Commission Decision Documents at 16 (September 8, 2006) (criticizing Commission for failing to publicly release a SECY paper (subsequently revealed to be SECY-04-0222) that “requested that consideration of the impacts of security event consequences be limited to prompt deaths”).

In responding to interrogatories by SLOMFP, the NRC Staff asserted that “[i]n general, the NRC considers potential offsite radiological contamination of land a potential environmental impact using NEPA criteria to assess its significance.” NRC Staff’s Response and Objections to San Luis Obispo Mothers for Peace’s First Set of Discovery Requests at 19 (February 22, 2008). This statement is inconsistent with the memoranda discussed above; with the statements in the Final EA Supplement regarding the Staff’s exclusive focus on immediate fatalities; and with the evidence established in Dr. Thompson’s Report and his Second Declaration that credible attacks on the Diablo Canyon ISFSI could result in significant levels of offsite contamination, causing

widespread health, environmental and economic effects. Thus, the Staff's interrogatory response must be rejected as totally inconsistent with the record.

**3. The EA Supplement arbitrarily limits its consideration of impacts.**

The NRC Staff has not disclosed any information about the attack-induced atmospheric releases that it has considered in the context of the Diablo Canyon ISFSI. However, some information about those releases can be inferred from available sources, including reference documents produced by the NRC Staff during discovery.

In the redacted portions of its reference documents, the Staff has disclosed some information about a study conducted for NRC by SNL, regarding the impact of a large aircraft on a field of HI-STORM spent-fuel-storage modules. That type of module would be used at the Diablo Canyon ISFSI. The study was described in Smith, et al., *Results of a Large Airplane Impact Into a Field of Holtec HI-STORM Spent Nuclear Fuel Casks* (Sandia National Laboratories, 2004) (Vaughn Index Document No. 1).<sup>7</sup> At page 7, the redacted report stated that the mass of the assumed aircraft is representative of the class of aircraft involved in the 9/11 events. At pages 24-25, the report stated that it is unlikely that a pool of fuel and a storage module would be co-located after the dynamic phase of the impact had concluded. Thus, a long-duration pool fire affecting a module was judged to be a non-credible event. At page C-4, the report mentioned the analytic simulation of a quiescent, engulfing fire affecting an upright module. The simulation was run for a short time – 90 to 180 seconds – consistent with SNL's judgment that a module would not be co-located with a long-duration pool fire. Second Thompson Declaration, par. VI-2.

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<sup>7</sup> Most of the content of this document was redacted.

Another report described a study conducted by SNL for NRC on the response of a HI-STORM 100 module to an explosive blast. Marlin E. Kipp, et al., *Response of the HI-STORM Spent Nuclear Fuel Storage Cask to a Large Explosive Charge Blast (U)* (Sandia National Laboratories, August 22, 2004).<sup>8</sup> At page 8 the redacted report stated:

The amount of explosive and standoff distance is representative of a scenario of a small truck parked directly adjacent to the cask. The scenario parameters for this event were defined by NRC design basis threat criteria and by NRC staff, where more specificity was required to define the event. This loading simulates a truck delivery of the explosive, parked adjacent to the cask.

At page 21 the report stated:

The charge configuration is limited to a bare TNT charge in close proximity to the cask.

Using the typology set forth in Table 3 of the Second Thompson Declaration, the two attack scenarios described above would be associated with Type III atmospheric releases. Both scenarios would have a dramatic appearance, but neither would represent a sophisticated approach to maximizing radiological impacts. Neither scenario would be likely to initiate sustained combustion of zircaloy cladding inside a module. Both scenarios would be consistent with atmospheric releases similar to the two scenarios discussed above. For such releases, the dominant radiological impact would be the inhalation doses accrued by persons exposed to the radioactive plume. Second Thompson Declaration, par. VI-4.<sup>9</sup>

In comparison, the radiological releases from an attack causing sustained

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<sup>8</sup> Again, most of the content of this document was redacted from the version provided to SLOMFP.

<sup>9</sup> As discussed in Section IV of the Second Thompson Declaration, the NRC's modeling of radioactive plume dispersion for purposes of assessing radiation dose is

combustion of zircaloy cladding inside a module would contain much larger amounts of volatile isotopes such as cesium-137, which would be significant from the perspective of land contamination (Type IV atmospheric releases designated in Table 3 of the Second Thompson Declaration). Second Thompson Declaration, par. V-11.

A superficial assessment of the vulnerability of an ISFSI might lead to the conclusion that Type IV releases deserve less consideration than do Type III releases because they would have a less dramatic appearance. That assessment would be incorrect. It would ignore the greater sophistication of the attack scenarios associated with Type IV releases, which would aim to maximize radiological impacts rather than the dramatic appearance of the event. Also, analysts whose attention is focused on the inhalation dose to a downwind individual could fail to appreciate the significance of Type IV releases, if they assume that the more dramatic-appearing attack scenarios associated with Type III releases would yield larger amounts of the isotopes that dominate inhalation dose. *Id.*

**4. NEPA requires the NRC Staff to prepare an EIS that encompasses a comprehensive assessment of the environmental impacts of an attack on the Diablo Canyon ISFSI.**

The NRC Staff argues that the environmental impacts of potential attacks on the Diablo Canyon ISFSI are not significant. But the Staff has not provided a comprehensive assessment to support that position. Second Thompson Declaration, par. VI-5. A comprehensive assessment would consider a range of attack scenarios, release types, and weather conditions. It would also address site-specific issues, including the complexities of atmospheric plume dispersion at the Diablo Canyon site. *Id.* In addition, as discussed

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unacceptably simplistic and stylized.

above, the Staff has not disclosed all of the assumptions that underlie its position. Thus, much of the basis for the Staff's position remains hidden.

The NRC Staff should identify and characterize a range of credible attacks, and then estimate the release of radioactive material to the environment for each type of attack. In the case of an attack on an ISFSI, the most significant mode of release would be to the atmosphere. Next, the assessment would model the dispersal of radioactive material in the environment. That step would include site-specific factors that significantly affect the behavior of atmospheric plumes. Then, the assessment would estimate human exposure to the released radioactive material by all significant pathways. Finally, the assessment would estimate the health, environmental, social and economic impacts, both direct and indirect, that rise from the potential for attack-induced release of radioactive material. Thompson Declaration, par. II-5.

## **VIII. CONCLUSION**

As demonstrated above, in the Thompson Report, and the Second Thompson Declaration, the EA Supplement prepared by the NRC Staff violates NEPA because it is not rigorous, comprehensive or science-based. The Staff ignored credible attack scenarios that could cause widespread and severe land contamination, leading to significant adverse health, environmental, and economic consequences. Moreover, compelling evidence indicates that in disregarding these clearly significant impacts, the Staff applied a secret NRC policy of excluding consideration of any impacts other than immediate fatalities.

Accordingly, the Commission should rule that under 10 C.F.R. § 2.1115(a)(2) there is no unresolved dispute of law or fact regarding Contention 2, and that SLOMFP

should prevail on the claims raised in the contention. Therefore PG&E's application for a license for the Diablo Canyon ISFSI should be denied unless and until the Staff prepares an EIS that fully addresses the environmental impacts of an attack on the Diablo Canyon ISFSI, as well as a range of reasonable alternatives for mitigating or avoiding those impacts.

Respectfully submitted,



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April 14, 2008

## CERTIFICATE OF SERVICE

I certify that on April 14, 2008, copies of SAN LUIS OBISPO MOTHERS FOR PEACE'S DETAILED SUMMARY OF FACTS, DATA, AND ARGUMENTS ON WHICH IT INTENDS TO RELY AT ORAL ARGUMENT TO DEMONSTRATE THE INADEQUACY OF THE U.S. NUCLEAR REGULATORY COMMISSION'S FINAL SUPPLEMENT TO THE ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED DIABLO CANYON INDEPENDENT SPENT FUEL STORAGE INSTALLATION TO CONSIDER THE ENVIRONMENTAL IMPACTS OF AN ATTACK ON THE FACILITY (CONTENTION 2) were served on the following persons by e-mail and first-class mail:

<p>Office of the Secretary (original and two copies) Rules and Adjudications Branch U.S. Nuclear Regulatory Commission 11555 Rockville Pike Rockville, MD 20852 Also by e-mail to: <a href="mailto:hearingdocket@nrc.gov">hearingdocket@nrc.gov</a></p>	<p>William V. Manheim, Esq. Jennifer Post Pacific Gas &amp; Electric Co. 77 Beale Street B30A San Francisco, CA 94105 Also by e-mail to: <a href="mailto:AxFn@pge.com">AxFn@pge.com</a>, <a href="mailto:JLKm@pge.com">JLKm@pge.com</a></p>
<p>David A. Repka, Esq. Tyson R. Smith, Esq. Winston &amp; Strawn, LLP 1700 K Street N.W. Washington, D.C. 20006-3817 Also by e-mail to: <a href="mailto:drepka@winston.com">drepka@winston.com</a>, <a href="mailto:trsmith@winston.com">trsmith@winston.com</a></p>	<p>Lisa B. Clark, Esq. Molly Barkman, Esq. Office of General Counsel Mail Stop O-15D21 U.S. Nuclear Regulatory Commission Washington, D.C. 20555 Also by e-mail to: <a href="mailto:lbc@nrc.gov">lbc@nrc.gov</a> ; <a href="mailto:Molly.barkman@nrc.gov">Molly.barkman@nrc.gov</a></p>
<p>Timothy McNulty, Esq. Office of County Counsel County Government Center Room 386 San Luis Obispo, CA 93408 Also by e-mail to: Also by e-mail to: <a href="mailto:tmcnulty@co.slo.ca.us">tmcnulty@co.slo.ca.us</a></p>	<p>Kenneth Alex, Esq. Susan Durbin, Esq. Brian Hembacher, Esq. California Department of Justice 1515 Clay Street, 20<sup>th</sup> Floor Oakland, CA 94612-0550 Also by e-mail to: <a href="mailto:Susan.Durbin@doj.ca.gov">Susan.Durbin@doj.ca.gov</a>; <a href="mailto:Brian.Hembacher@doj.ca.gov">Brian.Hembacher@doj.ca.gov</a></p>

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Diane Curran

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

In the Matter of: :  
: :  
PACIFIC GAS & ELECTRIC CO. : Docket No. 72-26 - ISFSI  
(Diablo Canyon Nuclear Power Plant :  
Unit Nos. 1 and 2) :

**DECLARATION OF DR. GORDON R. THOMPSON  
IN SUPPORT OF SAN LUIS OBISPO MOTHERS FOR PEACE'S (SLOMFP'S)  
CONTENTIONS REGARDING THE DIABLO CANYON ENVIRONMENTAL  
ASSESSMENT SUPPLEMENT**

Under penalty of perjury, I, Gordon R. Thompson, declare as follows:

1. I am the executive director of the Institute for Resource and Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. Our office is located at 27 Ellsworth Avenue, Cambridge, MA 02139. IRSS was founded in 1984 to conduct technical and policy analysis and public education, with the objective of promoting peace and international security, efficient use of natural resources, and protection of the environment. I am an expert in the technical analysis of safety, security and environmental issues related to nuclear facilities. A copy of my curriculum vitae is attached.
2. I received an undergraduate education in science and mechanical engineering at the University of New South Wales, in Australia. Subsequently, I pursued graduate studies at Oxford University and received from that institution a Doctorate of Philosophy in mathematics in 1973, for analyses of plasmas undergoing thermonuclear fusion. During my graduate studies I was associated with the fusion research program of the UK Atomic Energy Authority. My undergraduate and graduate work provided me with a rigorous education in the methodologies and disciplines of science, mathematics, and engineering.
3. Since 1977, a significant part of my work has consisted of technical analyses of safety, security and environmental issues related to nuclear facilities. These analyses have been sponsored by a variety of nongovernmental organizations and local, state and national governments, predominantly in North America and Western Europe. Drawing upon these analyses, I have provided expert testimony in legal and regulatory proceedings, and have served on committees advising US government agencies. To illustrate my expertise, I provide in the following paragraphs some details of my experience.

4. I have conducted, directed, and/or participated in a number of studies that evaluated aspects of the design and operation of nuclear facilities with respect to severe accident probabilities and consequences. These include generic studies and studies of individual facilities. For instance, with respect to generic studies on the potential for severe accidents at nuclear power plants, I was co-investigator in a study by the Union of Concerned Scientists on the "source term" issue -- the potential for release of radioactive material to the environment.<sup>1</sup> Also, I was one of a team of four scientists who prepared, for Greenpeace International, a comprehensive critique of the state of the art of probabilistic risk assessment (PRA) for nuclear power plants.<sup>2</sup> Our report noted that acts of malice, such as sabotage and acts of war, are not considered in PRAs, despite a history of malicious acts at many nuclear facilities. In addition, I conducted analysis on the relevance of PRA to emergency response planning, as part of a study on emergency planning for nuclear power plant accidents.<sup>3</sup> All of these studies required me to be highly familiar with the design and operation of nuclear power plants, as well as the characteristics of probabilistic risk assessment.

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

6. To a significant degree, my work has been accepted or adopted by relevant governmental agencies. During the period 1978-1979, for example, I served on an international review group commissioned by the government of Lower Saxony (a state in Germany) to evaluate a proposal for a nuclear fuel cycle center at Gorleben. I led the subgroup that examined accident risks and identified alternative options with lower risk.<sup>4</sup> One of the risk issues that I identified and analyzed was the potential for self-sustaining,

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<sup>1</sup> Steven Sholly and Gordon Thompson, The Source Term Debate (Cambridge, Massachusetts: Union of Concerned Scientists, January 1986).

<sup>2</sup> H Hirsch et al, IAEA Safety Targets and Probabilistic Risk Assessment (Hannover, Germany: Gesellschaft für Ökologische Forschung und Beratung mbH, August 1989).

<sup>3</sup> D Golding et al, Preparing for Nuclear Power Plant Accidents (Boulder, Colorado: Westview Press, 1995).

<sup>4</sup> Jan Beyea, Yves Lenoir, Gene Rochlin and Gordon Thompson (subgroup chair), Report of the Gorleben International Review, Chapter 3: Potential Accidents and their Effects, submitted (in German) to the Government of Lower Saxony, March 1979.

exothermic oxidation reactions of fuel cladding in a high-density spent fuel pool if water is lost from the pool. Hereafter, for simplicity, this event is referred to as a "pool fire".<sup>5</sup> In examining the potential for a pool fire, I identified partial loss of water as a more severe condition than total loss of water. I identified a variety of events that could cause a loss of water from a pool, including aircraft crash, sabotage, terrorism and acts of war. Also, I identified and described alternative fuel storage options with lower risk; these lower-risk options included design features such as spatial separation, natural cooling and underground vaults. The Lower Saxony government accepted my findings about the risk of a pool fire, and ruled in May 1979 that high-density pool storage of spent fuel was not an acceptable option at Gorleben. As a direct result, policy throughout Germany has been to use dry storage in casks, rather than high-density pool storage, for away-from-reactor storage of spent fuel.

7. My work has also influenced decision making by safety officials in the U.S. Department of Energy (DOE). During the period 1986-1991, I was commissioned by environmental groups to assess the safety of the military production reactors at the Savannah River Site, and to identify and assess alternative options for the production of tritium for the US nuclear arsenal. Initially, much of the relevant information was classified or otherwise inaccessible to the public. Nevertheless, I addressed safety issues through analyses that were recognized as accurate by nuclear safety officials at DOE. I eventually concluded that the Savannah River reactors could not meet the safety objectives set for them by DOE.<sup>6</sup> DOE subsequently reached the same conclusion, and scrapped the reactors. The current national policy for tritium production is to employ commercial reactors, an option that I had concluded was technically attractive but problematic from the perspective of nuclear weapons proliferation.

8. In 1977, and again during the period 1996-2000, I examined the safety of nuclear fuel reprocessing and liquid high-level radioactive waste management facilities at the Sellafield site in the UK. My investigation in the latter period was supported by consortia of local governments in Ireland and the UK, and I presented my interim findings at briefings in the UK and Irish parliaments in 1998. I identified safety issues that were not addressed in any publicly available literature about the Sellafield site.<sup>7</sup> As a

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<sup>5</sup> At water-cooled reactors, such as those at Diablo Canyon, the fuel cladding is made from a zirconium alloy that can enter into a vigorous exothermic oxidation reaction with either air or steam. For simplicity, this reaction can be referred to as a "fire".

<sup>6</sup> Gordon Thompson and Steven C Sholly, No Restart for K Reactor (Cambridge, Massachusetts: Institute for Resource and Security Studies, October 1991).

<sup>7</sup> Gordon Thompson, High Level Radioactive Liquid Waste at Sellafield: Risks, Alternative Options and Lessons for Policy (Cambridge, Massachusetts: Institute for Resource and Security Studies, June 1998).

direct result of my investigation, the UK Nuclear Installations Inspectorate (NII) required the operator of the Sellafield site -- British Nuclear Fuels (BNFL) -- to conduct extensive safety analyses. These analyses confirmed the significance of the safety issues that I had identified, and in January 2001 the NII established a legally binding schedule for reduction of the inventory of liquid high-level radioactive waste at Sellafield.<sup>8</sup> The NII took this action in recognition of the grave offsite consequences of a release to the environment from the tanks in which liquid high-level waste is stored. I had identified a variety of events that could cause such a release, including acts of malice or insanity.

9. In May 2000 I completed a study for Greenpeace International on the hazard potential of the La Hague site in France.<sup>9</sup> Nuclear fuel reprocessing and related activities are conducted at this site. The operator of the site -- COGEMA -- was authorized to store 14,000 tonnes of spent fuel in high-density pools at La Hague, and proposed to increase the capacity of these pools to 17,600 tonnes. My study described the potential for a pool fire at La Hague, and identified events -- including acts of malice or insanity -- that could lead to a pool fire. One of the findings of my study was that neither COGEMA nor the French government had a thorough understanding of La Hague's hazard potential, including the potential for a pool fire. Subsequent to the attacks of 11 September 2001 in New York and Washington, media exposure brought La Hague's hazard potential to the attention of the French government. During October 2001 the French government deployed anti-aircraft missiles at La Hague.

10. As stated in paragraph 6, I determined in the period 1978-1979 that partial loss of water from a high-density spent fuel pool is a more severe condition than total loss of water. This is because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies. During any scenario for loss of water from a spent fuel pool, there will be a period of time during which residual water is present. As a result, comparatively old fuel -- potentially including fuel aged 10 or more years after discharge from a reactor -- can ignite if water is lost from a high-density spent fuel pool. The NRC Staff failed, for more than two decades, to understand this point. An illustration of the Staff's lack of understanding was provided by its statements during a license amendment proceeding in regard to the expansion of spent fuel pool capacity at the Harris nuclear power plant. I served as an expert witness for Orange County, North Carolina, the intervenor in this proceeding. In filings during March and April 2000, the

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<sup>8</sup> Nuclear Installations Inspectorate, "Specification Issued under Licence Condition 32(4) for the Limitation of the Accumulation or Storage of Liquid High Level Radioactive Waste in B215. Licence Instrument 343. January 2001."

<sup>9</sup> Gordon Thompson, Hazard Potential of the La Hague Site: An Initial Review (Cambridge, Massachusetts: Institute for Resource and Security Studies, May 2000).

Staff repeatedly disparaged my statements that comparatively old fuel can ignite. A few months later, however, the Staff adopted my position. In a report dated October 2000, but not published until January 2001, the Staff recognized that the flow of air to exposed fuel assemblies could be blocked by the presence of collapsed structures -- which might be attributable, for example, to a cask drop or an earthquake -- or by the presence of residual water.<sup>10</sup> The Staff analyzed the heat transfer implications of flow blockage and concluded:<sup>11</sup>

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

11. On numerous occasions, I have drawn attention in my writings and oral presentations to the vulnerability of nuclear facilities to acts of malice or insanity. I have pointed out that PRAs do not address acts of malice or insanity, with the result that a PRA can, at best, provide a lower bound to the probability of a release of radioactive material.<sup>12</sup> In 1996 I wrote a generic report on war and terrorism as risk factors for nuclear power plants.<sup>13</sup> Among other findings, this report noted that an act of war or terrorism at a nuclear power plant might have as its primary target the spent fuel stored at the plant, rather than the reactor. The report concluded with a statement that:

"Public debate about the future operation of existing nuclear power plants, and the construction of new plants, should be broadened to encompass the possible involvement of nuclear plants in war or terrorism."

12. I am familiar with the License Application, Safety Analysis Report, and Environmental Report for Pacific Gas & Electric Company's proposed Independent Fuel Storage Installation on the site of the Diablo Canyon nuclear power plant.

13. I am also familiar with the NRC's Supplement to the Environmental Assessment and Draft Finding of No Significant Impact Related to the Construction and Operation of the

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<sup>10</sup> Timothy Collins et al (authors are all from the NRC Staff), Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, October 2000.

<sup>11</sup> Collins et al, October 2000 (op cit), page 2-1.

<sup>12</sup> The strengths and weaknesses of PRA methodology are discussed in Hirsch et al, August 1989 (op cit).

<sup>13</sup> Gordon Thompson, War, Terrorism and Nuclear Power Plants (Canberra: Peace Research Centre, Australian National University, October 1996).

Diablo Canyon Independent Spent Fuel Storage Installation (May 29, 2007) ("Diablo EA Supplement"). I have prepared a report that includes an analysis of the deficiencies in the Diablo EA Supplement's evaluation of the environmental impacts of intentional attacks on the proposed Diablo Canyon spent fuel storage facility: *Assessing Risks of Potential Malicious Actions at Commercial Nuclear Facilities: The Case of a Proposed Independent Spent Fuel Storage Installation at the Diablo Canyon Site* ("Report").

14. I also assisted SLOMFP in the preparation of its contentions regarding the Diablo EA Supplement.

15. The statements of fact in SLOMFP's contentions and my Report are true and correct to the best of my knowledge, and the opinions set forth therein are based on my best professional judgment.

16. I am prepared to testify as an expert witness on behalf of SLOMFP with respect to the facts and opinions set forth in SLOMFP's contentions and my Report.

A handwritten signature in cursive script that reads "G.R. Thompson". The signature is written in black ink and is positioned above a horizontal line.

Gordon R. Thompson, D.Phil

June 27, 2007

**Curriculum Vitae for Gordon R. Thompson**  
**October 2006**

Professional expertise

- Technical and policy analysis in the fields of energy, environment, sustainable development, human security, and international security.

Current appointments

- Executive director, Institute for Resource & Security Studies (IRSS), Cambridge, Massachusetts (since 1984).
- Research Professor, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts (since 2002).

Education

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

Project sponsors and tasks (selected)

- World Health Organization, 2006: conducted policy analysis on the potential for "health-bridge" programs to improve cooperation within and between nations.
- Attorney General of Massachusetts, 2006: conducted technical analysis and provided expert testimony regarding risks of storing spent fuel at nuclear power plants.
- Various sponsors, 2006: co-coordinated the Working Group on US-Iran Health Science Cooperation.
- Minnesota Center for Environmental Advocacy, and Minnesotans for an Energy Efficient Economy, 2005-2006: conducted technical analysis and provided expert testimony regarding management of spent fuel from the Monticello nuclear power plant.
- California Energy Commission, 2005: conducted technical analysis and participated in an expert workshop regarding safety and security of commercial nuclear facilities.
- Committee on Radioactive Waste Management (a committee appointed by the UK government), 2005: provided expert advice and technical analysis on safety and security of radioactive waste management.
- Legal Resources Centre, Cape Town, South Africa, 2004-2005: conducted technical analysis regarding the proposed South African pebble bed modular nuclear reactor.
- STAR Foundation, New York, 2002-2004: reviewed planning and actions for decommissioning of research reactors at Brookhaven National Laboratory.
- Attorney General of Utah, 2003: conducted technical analysis and provided expert testimony regarding a proposed national storage facility for spent nuclear fuel.

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- Mothers for Peace, California, 2002-2004: analyzed risk issues and prepared expert testimony associated with the Diablo Canyon nuclear power plant.
- Citizens Awareness Network, Massachusetts, 2002-2003: conducted analysis on robust storage of spent nuclear fuel.
- Tides Center, California, 2002-2004: conducted analysis for the Santa Susana Field Laboratory (SSFL) Advisory Panel regarding the history of releases of radioactive material from the SSFL.
- Orange County, North Carolina, 1999-2002: assessed risk issues associated with the Harris nuclear power plant, identified risk-reduction options, and prepared expert testimony.
- William and Flora Hewlett Foundation and other sponsors, 1999-2006: performed research and project development for conflict-management projects, through IRSS's International Conflict Management Program.
- STAR Foundation, New York, 2000-2001: assessed risk issues associated with the Millstone nuclear power plant, identified risk-reduction options, and prepared expert testimony.
- Massachusetts Water Resources Authority, 2000: evaluated risks associated with water supply and wastewater systems that serve greater Boston.
- Canadian Senate, Energy & Environment Committee, 2000: reviewed risk issues associated with the Pickering Nuclear Generating Station.
- Greenpeace International, Amsterdam, 2000: reviewed impacts associated with the La Hague nuclear complex in France.
- Government of Ireland, 1998-2001: developed framework for assessment of impacts and alternative options associated with the Sellafield nuclear complex in the UK.
- Clark University, Worcester, Massachusetts, 1998-1999: participated in confidential review of outcomes of a major foundation's grants related to climate change.
- UN High Commissioner for Refugees, 1998: developed a strategy for conflict management in the CIS region.
- General Council of County Councils (Ireland), W. Alton Jones Foundation (USA), and Nuclear Free Local Authorities (UK), 1996-2000: assessed safety and economic issues of nuclear fuel reprocessing in the UK; assessed alternative options.
- Environmental School, Clark University, Worcester, Massachusetts, 1996: session leader at the Summer Institute, "Local Perspectives on a Global Environment".
- Greenpeace Germany, Hamburg, 1995-1996: a study on war, terrorism and nuclear power plants.
- HKH Foundation, New York, and Winston Foundation for World Peace, Washington, DC, 1994-1996: studies and workshops on preventive action and its role in US national security planning.
- Carnegie Corporation of New York, Winston Foundation for World Peace, Washington, DC, and others, 1995: collaboration with the Organization for Security and Cooperation in Europe to facilitate improved coordination of activities and exchange of knowledge in the field of conflict management.
- World Bank, 1993-1994: a study on management of data describing the performance of projects funded by the Global Environment Facility (joint project of IRSS and Clark University).

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- International Physicians for the Prevention of Nuclear War, 1993-1994: a study on the international control of weapons-usable fissile material.
- Government of Lower Saxony, Hannover, Germany, 1993: analysis of standards for radioactive waste disposal.
- University of Vienna (using funds supplied by the Austrian government), 1992: review of radioactive waste management at the Dukovany nuclear power plant, Czech Republic.
- Sandia National Laboratories, 1992-1993: advice to the US Department of Energy's Office of Foreign Intelligence.
- US Department of Energy and Battelle Pacific Northwest Laboratories, 1991-1992: advice for the Intergovernmental Panel on Climate Change regarding the design of an information system on technologies that can limit greenhouse gas emissions (joint project of IRSS, Clark University and the Center for Strategic and International Studies).
- Winston Foundation for World Peace, Boston, Massachusetts, and other funding sources, 1992-1993: development and publication of recommendations for strengthening the International Atomic Energy Agency.
- MacArthur Foundation, Chicago, Illinois, W. Alton Jones Foundation, Charlottesville, Virginia, and other funding sources, 1984-1993: policy analysis and public education on a "global approach" to arms control and disarmament.
- Energy Research Foundation, Columbia, South Carolina, and Peace Development Fund, Amherst, Massachusetts, 1988-1992: review of the US government's tritium production (for nuclear weapons) and its implications.
- Coalition of Environmental Groups, Toronto, Ontario (using funds supplied by Ontario Hydro under the direction of the Ontario government), 1990-1993: coordination and conduct of analysis and preparation of testimony on accident risk of nuclear power plants.
- Greenpeace International, Amsterdam, Netherlands, 1988-1990: review of probabilistic risk assessment for nuclear power plants.
- Bellerive Foundation, Geneva, Switzerland, 1989-1990: planning for a June 1990 colloquium on disarmament and editing of proceedings.
- Iler Research Institute, Harrow, Ontario, 1989-1990: analysis of regulatory response to boiling-water reactor accident potential.
- Winston Foundation for World Peace, Boston, Massachusetts, and other funding sources, 1988-1989: analysis of future options for NATO (joint project of IRSS and the Institute for Peace and International Security).
- Nevada Nuclear Waste Project Office, Carson City, Nevada (via Clark University), 1989-1990: analyses of risk aspects of radioactive waste management and disposal.
- Ontario Nuclear Safety Review (conducted by the Ontario government), Toronto, Ontario, 1987: review of safety aspects of CANDU reactors.
- Washington Department of Ecology, Olympia, Washington, 1987: analyses of risk aspects of a proposed radioactive waste repository at Hanford.
- Natural Resources Defense Council, Washington, DC, 1986-1987: preparation of expert testimony on hazards of the Savannah River Plant, South Carolina.
- Lakes Environmental Association, Bridgton, Maine, 1986: analysis of federal regulations for disposal of radioactive waste.
- Greenpeace Germany, Hamburg, 1986: participation in an international study on the hazards of nuclear power plants.

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- Three Mile Island Public Health Fund, Philadelphia, Pennsylvania, 1983-1989: studies related to the Three Mile Island nuclear power plant and emergency response planning.
- Attorney General, Commonwealth of Massachusetts, 1984-1989: analyses of the safety of the Seabrook nuclear power plant, preparation of expert testimony.
- Union of Concerned Scientists, Cambridge, Massachusetts, 1980-1985: studies on energy demand and supply, nuclear arms control, and the safety of nuclear installations.
- Conservation Law Foundation of New England, Boston, Massachusetts, 1985: preparation of expert testimony on cogeneration potential at a Maine paper mill.
- Town & Country Planning Association, London, UK, 1982-1984: coordination and conduct of a study on safety and radioactive waste implications of the proposed Sizewell nuclear power plant, testimony to the Sizewell Public Inquiry.
- US Environmental Protection Agency, Washington, DC, 1980-1981: assessment of the cleanup of Three Mile Island Unit 2 nuclear power plant.
- Center for Energy & Environmental Studies, Princeton University, Princeton, New Jersey, and Solar Energy Research Institute, Golden, Colorado, 1979-1980: studies on the potentials of renewable energy sources.
- Government of Lower Saxony, Hannover, Federal Republic of Germany, 1978-1979: coordination and conduct of studies on safety and security aspects of the proposed Gorleben nuclear fuel cycle center.

### Other experience (selected)

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

### Publications (selected)

- "Using Psychosocial Healing in Postconflict Reconstruction" (with Paula Gutlove), in Mari Fitzduff and Chris E. Stout (eds), *The Psychology of Resolving Global Conflicts: From War to Peace*, Praeger Security International, 2006.

- "What Role for Nuclear Power in a Sustainable Civilization?", *The Green Cross Optimist*, Spring 2006, pp 28-30.
- *Radiological Risk of Homeport Basing of a Nuclear-Propelled Aircraft Carrier in Yokosuka, Japan*, a report for the Citizens Coalition Concerning the Homeporting of a CVN in Yokosuka, 29 June 2006.
- *Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants*, a report for the Attorney General, Commonwealth of Massachusetts, 25 May 2006.
- *Reasonably Foreseeable Security Events: Potential threats to options for long-term management of UK radioactive waste*, a report for the UK Committee on Radioactive Waste Management, 2 November 2005.
- "Plasma, policy and progress", *The Australian Mathematical Society Gazette*, Volume 32, Number 3, 2005, pp 162-168.
- "A Psychosocial-Healing Approach to Post-Conflict Reconstruction" (with Paula Gutlove), *Mind & Human Interaction*, Volume 14, Number 1, 2005, pp 35-63.
- "Designing Infrastructure for New Goals and Constraints", Proceedings of the conference, *Working Together: R&D Partnerships in Homeland Security*, Boston, Massachusetts, 27-28 April 2005, sponsored by the US Department of Homeland Security. (A version of this paper has also been published as CRS Discussion Paper 2005-02, Center for Risk and Security, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts.)
- "Potential Radioactive Releases from Commercial Reactors and Spent Fuel", Proceedings of the conference, *Working Together: R&D Partnerships in Homeland Security*, Boston, Massachusetts, 27-28 April 2005, sponsored by the US Department of Homeland Security. (A version of this paper has also been published as CRS Discussion Paper 2005-03, Center for Risk and Security, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts.)
- *Safety of the Proposed South African Pebble Bed Modular Reactor*, a report for the Legal Resources Centre, Cape Town, South Africa, 12 January 2005.
- *Decommissioning of Research Reactors at Brookhaven National Laboratory: Status, Future Options and Hazards*, a report for STAR Foundation, East Hampton, New York, April 2004.
- "Psychosocial Healing and Post-Conflict Social reconstruction in the Former Yugoslavia" (with Paula Gutlove), *Medicine, Conflict and Survival*, Volume 20, Number 2, April-June 2004, pp 136-150.
- "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States" (with Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane and Frank N. von Hippel), *Science and Global Security*, Volume 11, 2003, pp 1-51.
- "Health, Human Security, and Social Reconstruction in Afghanistan" (with Paula Gutlove and Jacob Hale Russell), in John D. Montgomery and Dennis A. Rondinelli (eds), *Beyond Reconstruction in Afghanistan*, Palgrave Macmillan, 2004.
- *Psychosocial Healing: A Guide for Practitioners, based on programs of the Medical Network for Social Reconstruction in the Former Yugoslavia* (with Paula Gutlove), IRSS, Cambridge, Massachusetts and OMEGA Health Care Center, Graz, Austria, May 2003.

- *A Call for Action to Protect the Nation Against Enemy Attack on Nuclear Power Plants and Spent Fuel*, and a Supporting Document, Mothers for Peace, San Luis Obispo, California, April 2003 and May 2003.
- "Human Security: Expanding the Scope of Public Health" (with Paula Gutlove), *Medicine, Conflict and Survival*, Volume 19, 2003, pp 17-34.
- *Social Reconstruction in Afghanistan through the Lens of Health and Human Security* (with Paula Gutlove and Jacob Hale Russell), IRSS, Cambridge, Massachusetts, May 2003.
- *Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security*, a report for Citizens Awareness Network, Shelburne Falls, Massachusetts, January 2003.
- *Medical Network for Social Reconstruction in the Former Yugoslavia: A Survey of Participants' Views on the Network's Goals and Achievements*, IRSS, Cambridge, Massachusetts, September 2001.
- *The Potential for a Large, Atmospheric Release of Radioactive Material from Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release Initiated by a Severe Reactor Accident*, a report for Orange County, North Carolina, 20 November 2000.
- *A Review of the Accident Risk Posed by the Pickering 'A' Nuclear Generating Station*, a report for the Standing Committee on Energy, Environment and Natural Resources, Canadian Senate, August 2000.
- *High-Level Radioactive Liquid Waste at Sellafield: An Updated Review*, a report for the UK Nuclear Free Local Authorities, June 2000.
- *Hazard Potential of the La Hague Site: An Initial Review*, a report for Greenpeace International, May 2000.
- *A Strategy for Conflict Management: Integrated Action in Theory and Practice* (with Paula Gutlove), IRSS, Cambridge, Massachusetts, March 1999.
- *Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant*, a report for Orange County, North Carolina, February 1999.
- *High Level Radioactive Liquid Waste at Sellafield: Risks, Alternative Options and Lessons for Policy*, IRSS, Cambridge, Massachusetts, June 1998.
- "Science, democracy and safety: why public accountability matters", in F. Barker (ed), *Management of Radioactive Wastes: Issues for local authorities*, Thomas Telford, London, 1998.
- "Conflict Management and the OSCE" (with Paula Gutlove), *OSCE/ODIHR Bulletin*, Volume 5, Number 3, Fall 1997.
- *Safety of the Storage of Liquid High-Level Waste at Sellafield* (with Peter Taylor), Nuclear Free Local Authorities, UK, November 1996.
- *Assembling Evidence on the Effectiveness of Preventive Actions, their Benefits, and their Costs: A Guide for Preparation of Evidence*, IRSS, Cambridge, Massachusetts, August 1996.
- *War, Terrorism and Nuclear Power Plants*, Peace Research Centre, Australian National University, Canberra, October 1996.
- "The Potential for Cooperation by the OSCE and Non-Governmental Actors on Conflict Management" (with Paula Gutlove), *Helsinki Monitor*, Volume 6 (1995), Number 3.

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- "Potential Characteristics of Severe Reactor Accidents at Nuclear Plants", "Monitoring and Modelling Atmospheric Dispersion of Radioactivity Following a Reactor Accident" (with Richard Sclove, Ulrike Fink and Peter Taylor), "Safety Status of Nuclear Reactors and Classification of Emergency Action Levels", and "The Use of Probabilistic Risk Assessment in Emergency Response Planning for Nuclear Power Plant Accidents" (with Robert Goble), in D. Golding, J. X. Kasperson and R. E. Kasperson (eds), *Preparing for Nuclear Power Plant Accidents*, Westview Press, Boulder, Colorado, 1995.
- *A Data Manager for the Global Environment Facility* (with Robert Goble), Environment Department, The World Bank, June 1994.
- *Preventive Diplomacy and National Security* (with Paula Gutlove), Winston Foundation for World Peace, Washington, DC, May 1994.
- *Opportunities for International Control of Weapons-Usable Fissile Material*, International Physicians for the Prevention of Nuclear War, Cambridge, Massachusetts, January 1994.
- "Article III and IAEA Safeguards", in F. Barnaby and P. Ingram (eds), *Strengthening the Non-Proliferation Regime*, Oxford Research Group, Oxford, UK, December 1993.
- *Risk Implications of Potential New Nuclear Plants in Ontario* (prepared with the help of eight consultants), a report for the Coalition of Environmental Groups, Toronto, submitted to the Ontario Environmental Assessment Board, November 1992 (3 volumes).
- *Strengthening the International Atomic Energy Agency*, IRSS, Cambridge, Massachusetts, September 1992.
- *Design of an Information System on Technologies that can Limit Greenhouse Gas Emissions* (with Robert Goble and F. Scott Bush), Center for Strategic and International Studies, Washington, DC, May 1992.
- *Managing Nuclear Accidents: A Model Emergency Response Plan for Power Plants and Communities* (with six other authors), Westview Press, Boulder, CO, 1992.
- "Let's X-out the K" (with Steven C. Sholly), *Bulletin of the Atomic Scientists*, March 1992, pp 14-15.
- "A Worldwide Programme for Controlling Fissile Material", and "A Global Strategy for Nuclear Arms Control", in F. Barnaby (ed), *Plutonium and Security*, Macmillan Press, UK, 1992.
- *No Restart for K Reactor* (with Steven C. Sholly), IRSS, Cambridge, Massachusetts, October 1991.
- *Regulatory Response to the Potential for Reactor Accidents: The Example of Boiling-Water Reactors*, IRSS, Cambridge, Massachusetts, February 1991.
- *Peace by Piece: New Options for International Arms Control and Disarmament*, IRSS, Cambridge, Massachusetts, January 1991.
- *Developing Practical Measures to Prevent Climate Disruption* (with Robert Goble), CENED Research Report No. 6, Clark University, Worcester, Massachusetts, August 1990.
- "Treaty a Useful Relic", *Bulletin of the Atomic Scientists*, July/August 1990, pp 32-33.
- "Practical Steps for the 1990s", in Sadruddin Aga Khan (ed), *Non-Proliferation in a Disarming World*, Proceedings of the Groupe de Bellerive's 6th International Colloquium, Bellerive Foundation, Geneva, Switzerland, 1990.

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- *A Global Approach to Controlling Nuclear Weapons*, IRSS, Cambridge, Massachusetts, October 1989.
- *IAEA Safety Targets and Probabilistic Risk Assessment* (with three other authors), Greenpeace International, Amsterdam, August 1989.
- *New Directions for NATO* (with Paul Walker and Pam Solo), published jointly by IRSS and the Institute for Peace and International Security (both of Cambridge, Massachusetts), December 1988.
- "Verifying a Halt to the Nuclear Arms Race", in F. Barnaby (ed), *A Handbook of Verification Procedures*, Macmillan Press, UK, 1990.
- "Verification of a Cutoff in the Production of Fissile Material", in F. Barnaby (ed), *A Handbook of Verification Procedures*, Macmillan Press, UK, 1990.
- "Severe Accident Potential of CANDU Reactors," Consultant's Report in *The Safety of Ontario's Nuclear Power Reactors*, Ontario Nuclear Safety Review, Toronto, February 1988.
- *Nuclear-Free Zones* (edited with David Pitt), Croom Helm Ltd, Beckenham, UK, 1987.
- *Risk Assessment Review For the Socioeconomic Impact Assessment of the Proposed High-Level Nuclear Waste Repository at Hanford Site, Washington* (edited; written with five other authors), prepared for the Washington Department of Ecology, December 1987.
- *The Nuclear Freeze Revisited* (with Andrew Haines), Nuclear Freeze and Arms Control Research Project, Bristol, UK, November 1986. Variants of the same paper have appeared as Working Paper No. 18, Peace Research Centre, Australian National University, Canberra, February 1987, and in *ADIU Report*, University of Sussex, Brighton, UK, Jan/Feb 1987, pp 6-9.
- *International Nuclear Reactor Hazard Study* (with fifteen other authors), Greenpeace, Hamburg, Federal Republic of Germany (2 volumes), September 1986.
- "What happened at Reactor Four" (the Chernobyl reactor accident), *Bulletin of the Atomic Scientists*, August/September 1986, pp 26-31.
- *The Source Term Debate: A Report by the Union of Concerned Scientists* (with Steven C. Sholly), Union of Concerned Scientists, Cambridge, Massachusetts, January 1986.
- "Checks on the spread" (a review of three books on nuclear proliferation), *Nature*, 14 November 1985, pp 127-128.
- Editing of *Perspectives on Proliferation*, August 1985, published by the Proliferation Reform Project, IRSS.
- "A Turning Point for the NPT ?", *ADIU Report*, University of Sussex, Brighton, UK, Nov/Dec 1984, pp 1-4.
- "Energy Economics", in J. Dennis (ed), *The Nuclear Almanac*, Addison-Wesley, Reading, Massachusetts, 1984.
- "The Genesis of Nuclear Power", in J. Tirman (ed), *The Militarization of High Technology*, Ballinger, Cambridge, Massachusetts, 1984.
- *A Second Chance: New Hampshire's Electricity Future as a Model for the Nation* (with Linzee Weld), Union of Concerned Scientists, Cambridge, Massachusetts, 1983.
- *Safety and Waste Management Implications of the Sizewell PWR* (prepared with the help of six consultants), a report to the Town & Country Planning Association, London, UK, 1983.

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

Expert presentations and testimony (selected)

- Minnesota Public Utilities Commission, 2006: testimony regarding trends, risks and costs associated with management of spent fuel from the Monticello nuclear power plant.
- Presentation, "Are Nuclear Installations Terrorist Targets?", at the conference, *Nuclear Energy: Does it Have a Future?*, Drogheda, County Louth, Ireland; 10-11 March 2005.
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- European Parliament, 2003: invited presentation to EP members regarding safety and security issues at the Sellafield nuclear site in the UK, and broader implications.
- US Congress, 2002 and 2003: invited presentations at member-sponsored staff briefings on vulnerabilities of nuclear-power facilities to attack and options for improved defenses.
- Numerous public forums in the USA, 2001-2006: invited presentations to public officials and general audiences regarding vulnerabilities of nuclear-power facilities to attack and options for improved defenses.
- UK Consensus Conference on Radioactive Waste Management, 1999: invited testimony on information and decision-making.
- Joint Committee on Public Enterprise and Transport, Irish Parliament, 1999: invited testimony on nuclear fuel reprocessing and international security.
- UK and Irish Parliaments, 1998: invited presentations to members on risks and alternative options associated with nuclear fuel reprocessing in the UK.
- Center for Russian Environmental Policy, Moscow, 1996: invited presentation at a forum in parallel with the G-7 Nuclear Safety Summit.
- Lacey Township Zoning Board, New Jersey, 1995: testimony regarding radioactive waste management.
- Ontario Court of Justice, Toronto, Ontario, 1993: testimony regarding Canada's Nuclear Liability Act.
- Oxford Research Group, seminar on "The Plutonium Legacy", Rhodes House, Oxford, UK, 1993: invited presentation on nuclear safeguards.

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- Conference to consider amending the Partial Test Ban Treaty, United Nations, New York, 1991: presentation on a global approach to arms control and disarmament.
- US Department of Energy, hearing on draft EIS for new production reactor capacity, Columbia, South Carolina, 1991: testimony on tritium need and implications of tritium production options.
- Society for Risk Analysis, 1990 annual meeting, New Orleans, special session on nuclear emergency planning: presentation on real-time techniques for anticipating emergencies.
- Parliamentarians' Global Action, 11th Annual Parliamentary Forum, United Nations, Geneva, 1990: invited presentation on the potential for multilateral nuclear arms control.
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- Peace Research Centre, Australian National University, seminar on "Australia and the Fourth NPT Review Conference", Canberra, 1989: invited presentation regarding a universal nuclear weapons non-proliferation regime.
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- Atomic Safety & Licensing Board, US Nuclear Regulatory Commission, 1983: testimony on use of filtered venting at the Indian Point nuclear power plant.
- US National Advisory Committee on Oceans and Atmosphere, 1982: testimony on implications of ocean disposal of radioactive waste.
- Environmental & Energy Study Conference, US Congress, 1982: invited presentation on implications of radioactive waste management.

Miscellaneous

- Married, two children.
- Extensive experience in public speaking and interviews by representatives of print and electronic media.
- Author of numerous essays and letters in newspapers and magazines.

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ASSESSING RISKS OF  
POTENTIAL MALICIOUS ACTIONS  
AT COMMERCIAL NUCLEAR FACILITIES:  
The Case of a Proposed  
Independent Spent Fuel Storage Installation  
at the Diablo Canyon Site

by  
Gordon R. Thompson

27 June 2007

A report for  
San Luis Obispo Mothers for Peace  
California

**Abstract**

This report discusses the risks of potential malicious actions at commercial nuclear facilities in the US, with a focus on actions by sub-national groups. These risks are first discussed generically, with a focus on power reactors, their spent fuel pools, and independent spent fuel storage installations (ISFSIs) at reactor sites. The report then provides a more detailed discussion of malice-related risks at a proposed ISFSI at the Diablo Canyon site in California. In May 2007 the US Nuclear Regulatory Commission Staff issued a Supplement to its October 2003 Environmental Assessment (EA) for the Diablo Canyon ISFSI. The Supplement considered malice-related risks, pursuant to a ruling by the 9th Circuit of the US Court of Appeals that these risks should have been considered in the EA. The Supplement is reviewed here.

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**About the Institute for Resource and Security Studies**

The Institute for Resource and Security Studies (IRSS) is an independent, nonprofit, Massachusetts corporation, founded in 1984. Its objective is to promote sustainable use of natural resources and global human security. In pursuit of this mission, IRSS conducts technical and policy analysis, public education, and field programs. IRSS projects always reflect a concern for practical solutions to resource and security problems.

**About the Author**

Gordon R. Thompson is the executive director of IRSS and a research professor at Clark University, Worcester, Massachusetts. He studied and practiced engineering in Australia, and received a doctorate in applied mathematics from Oxford University in 1973, for analyses of plasma undergoing thermonuclear fusion. Dr. Thompson has been based in the USA since 1979. His professional interests encompass a range of technical and policy issues related to global human security and sustainable use of natural resources. He has conducted numerous studies on the environmental impacts of nuclear facilities, and on options for reducing these impacts.

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## **1. Introduction**

A variety of nuclear facilities are deployed across the United States and worldwide to serve commercial (non-military) purposes. These facilities contain radioactive material and fissionable material that could create adverse impacts if released to the environment or used for unauthorized purposes. Those impacts could arise as a result of conventional accidents or malicious actions. Here, the term "conventional accidents" refers to incidents caused by human error, equipment failure or natural events.<sup>1</sup> Other incidents could be caused by deliberate, malicious actions. The parties taking those malicious actions<sup>2</sup> could be national governments or sub-national groups.<sup>2</sup>

This report discusses the risks of potential malicious actions at commercial nuclear facilities in the US, with a focus on actions by sub-national groups. The report also focuses on a particular set of facilities that contain large amounts of radioactive material. These facilities are reactors used for generating electrical power, and facilities at the reactor sites that store spent fuel discharged from the reactors. After discharge, spent fuel assemblies are initially stored in spent-fuel pools located adjacent to the reactors. Some years later, the assemblies could be transferred to an independent spent fuel storage installation (ISFSI) on the reactor site. ISFSIs are operating or under construction at a number of reactor sites in the US, and more are being proposed. Although this report focuses on power reactors, their spent-fuel pools, and ISFSIs at reactor sites, many of its findings are applicable to other commercial nuclear facilities.

Here, the term "risks" refers to potential adverse impacts that can be reasonably foreseen but will not necessarily occur. Such impacts can be characterized by their consequences and their probabilities of occurrence.<sup>3</sup> This report focuses on risks associated with potential radiological impacts arising from release to the environment of radioactive material as a result of malicious actions. Many of the report's findings are applicable to related types of risks, such as those associated with use of fissionable material for unauthorized purposes.

### *The Diablo EA Supplement*

In October 2003 the Nuclear Regulatory Commission (NRC) Staff issued an Environmental Assessment (EA) for a proposed ISFSI at the Diablo Canyon reactor site in California. The EA did not consider malice-related risks. Pursuant to a petition by

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<sup>1</sup> The NRC's Glossary, accessed at the NRC web site ([www.nrc.gov](http://www.nrc.gov)) on 25 June 2007, contains no definition of "accident". The term "conventional accident" is defined and used in this report to ensure precision, because the term "accident" has been used to encompass incidents caused by deliberate, malicious actions.

<sup>2</sup> Relevant sub-national groups could be based in the US or in other countries.

<sup>3</sup> Some analysts define "risk" as the arithmetic product of consequence and probability. That definition is simplistic and can be misleading, and is not used in this report. That definition is especially inappropriate for malice-related risks because there is usually no statistical basis to support quantitative estimates of the probabilities of malicious actions.

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San Luis Obispo Mothers for Peace and other parties, the 9th Circuit of the US Court of Appeals ruled in June 2006 that the EA was inadequate because it did not consider malice-related environmental impacts. In May 2007 the Staff responded to that ruling by issuing a Supplement to the October 2003 EA.<sup>4</sup> The Supplement addresses the risks of potential malicious actions at the proposed ISFSI. Hereafter, the Supplement is described as the "Diablo EA Supplement".

Over a three-decade period, the NRC has accepted, in various contexts, that an analysis of a nuclear facility's environmental impacts, in an EA or an environmental impact statement (EIS), should consider radiological risks associated with conventional accidents. The NRC has generally refused, however, to consider malice-related risks in an EA or EIS. The Diablo EA Supplement represents a departure from that longstanding refusal. The NRC Staff has issued an analogous document in the context of an application to build and operate an industrial irradiator in Hawaii.<sup>5</sup> Other, analogous documents are likely to be prepared in other licensing contexts. Thus, the Diablo EA Supplement deserves careful review.

This report provides a review of the Diablo EA Supplement. To support that review, the report also discusses some broader issues. The NRC has not issued any document or statement that provides an adequate discussion of the broader issues surrounding the Diablo EA Supplement.

Preparation of EAs and EISs is governed by the National Environmental Policy Act (NEPA). A major purpose of NEPA is to ensure that options for reducing the risks and other environmental impacts of a proposed action are identified and characterized. That goal is addressed repeatedly in this report.

*Sensitive information*

Any responsible analyst who discusses potential acts of malice at nuclear facilities is careful about making statements in public settings. The author of this report exercises such care. The author has no access to classified information, and this report contains no such information. However, a higher standard of discretion is necessary. An analyst should not publish sensitive information, defined here as detailed information that could substantially assist an attacking group to attain its objectives, even if this information is publicly available from other sources. On the other hand, secrecy has costs, and an entrenched culture of secrecy is not compatible with a clear-headed, science-based approach to the understanding of risks. Section 3.3 of this report provides a further discussion about identifying and managing sensitive information.

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<sup>4</sup> NRC, 2007a.

<sup>5</sup> NRC, 2007b.

*Structure of this report*

The remainder of this report has five sections. Section 2 provides a broad, US-wide perspective on potential malicious actions at commercial nuclear facilities. That potential is discussed within the contexts of the general threat environment and national policy on homeland security. Section 3 sets forth an appropriate framework for assessing the risks of malicious actions at nuclear facilities, and for incorporating the findings in an EA or EIS. In Section 4, the Diablo EA Supplement is reviewed, using the framework set forth in Section 3 as a standard that should be met. That review does not purport to provide analysis that corrects deficiencies in the Diablo EA Supplement. Providing such analysis is a task for the NRC Staff. Conclusions are set forth in Section 5, and a bibliography is provided in Section 6. All documents cited in the text of this report are listed in the bibliography.

**2. A US-Wide Perspective on Potential Malicious Actions at Nuclear Facilities**

**2.1 The General Threat Environment**

The potential for a deliberate attack on a commercial nuclear facility arises within a larger context, namely the general threat environment for the US homeland. That environment reflects, in turn, a complex set of factors operating internationally.

If the Diablo Canyon nuclear generation units receive 20-year license extensions, they will operate until 2041 (Unit 1) and 2045 (Unit 2), discharging spent fuel throughout that period. The proposed Yucca Mountain repository could not accommodate more than a fraction of the Diablo units' cumulative discharge of spent fuel, and it is increasingly unlikely that this repository will open. No other option is currently available for removing spent fuel from the Diablo Canyon site. At that site, as at nuclear power plant sites across the US, the most likely outcome is that spent fuel will be stored at the site for the foreseeable future, potentially for longer than a century.<sup>6</sup> Thus, in assessing the risks of malicious actions at a Diablo Canyon ISFSI, one should consider the general threat environment over the next century.

*The threat from sub-national groups*

The US homeland has not been attacked by another nation since World War II. One factor behind this outcome has been the US deployment of military forces with a high capability for counter-attack. There have, however, been significant attacks on the US homeland and other US assets by sub-national groups since World War II. Such attacks are typically not deterred by US capability for counter-attack, because the attacking group has no identifiable territory. Indeed, sub-national groups may attack US assets

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<sup>6</sup> Thompson, 2005a.

with the specific purpose of prompting US counter-attacks that harm innocent persons, thereby undermining the global political position of the US.

Attacks on the homeland by sub-national groups in recent decades include vehicle bombings of the World Trade Center in New York in February 1993 and the Murrah Federal building in Oklahoma City in April 1995, and aircraft attacks on the World Trade Center and the Pentagon in September 2001. Outside the homeland, attacks on US assets by sub-national groups have included vehicle-bomb attacks on a Marine barracks in Beirut in October 1983 and embassies in Tanzania and Kenya in August 1998, and a boat-bomb attack on the USS Cole in October 2000. At present, sub-national groups routinely attack US forces in Iraq.

In many of these incidents, the attacking group has been based outside the US. An exception was the Oklahoma City bombing, where the attacking group was domestic in both its composition and its motives. There is concern that future attacks within the US may be made by groups that are domestically based but have linkages to, or sympathy with, interests outside the US. This phenomenon was exhibited in London in July 2005, when young men born in the UK conducted suicide bombings in underground trains and a bus.

Reducing the risks of attack by sub-national groups requires a sophisticated, multi-faceted and sustained policy. An unbalanced policy can be ineffective or counterproductive. Since September 2001, the US government has implemented a policy that is heavily weighted toward offensive military action. Evidence is accumulating that this policy has been significantly counterproductive. Table 2-1 provides a sample of the evidence. The table shows recent public-opinion data from four Muslim-majority countries (Morocco, Egypt, Pakistan, Indonesia). In each country, a majority (ranging from 53 percent of respondents in Indonesia to 86 percent in Egypt) believes that the primary goal of the US "war on terrorism" is to weaken Islam or control Middle East resources (oil and natural gas). One expression of this belief is that substantial numbers of people (ranging from 19 percent of respondents in Indonesia to 91 percent in Egypt) approve of attacks on US troops in Iraq. Smaller numbers of people (ranging from 4 to 7 percent of respondents) approve of attacks on civilians in the US.<sup>7</sup>

The great majority of people, in these four countries and elsewhere, will not participate in attacks on US assets. However, there are consequences when millions of people believe that the US seeks to undermine their religion and culture and control their resources. Among other consequences, this belief creates a social climate that can help sub-national groups to form and to acquire the skills, funds and equipment they need in order to mount attacks. From a US perspective, such groups are "terrorists". Within their own cultures, they may be seen as soldiers engaged in "asymmetric warfare" with a powerful enemy.

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<sup>7</sup> Kull et al, 2007.

*The threat environment over the coming decades*

As mentioned above, an assessment of the risks of malicious actions at a Diablo Canyon ISFSI should consider the general threat environment over the next century. Forecasting trends in the threat environment over such a period is a daunting exercise, with inevitably uncertain findings. Nevertheless, if an ISFSI is constructed at Diablo Canyon, the security aspects of its design will reflect an implicit or explicit forecast of trends in the general threat environment. The forecast should be explicit, and should be global in scope, because the US cannot be insulated from broad trends in violent conflict and social disorder.

Numerous analysts – in academia, government and business – are involved in efforts to forecast possible worldwide trends that pertain to violence. These efforts rarely attempt to look forward more than one or two decades. Two examples are illustrative. First, a group based at the University of Maryland tracks a variety of indicators for most of the countries in the world, in a data base that extends back to 1950 and earlier. Using these data, the group periodically provides country-level assessments of the potential for outbreaks of violent conflict.<sup>8</sup> Second, the RAND corporation has conducted a literature review and assessment of potential worldwide trends that would be adverse for US national security.<sup>9</sup>

Several decades ago, some analysts of potential futures began taking an integrated world view, in which social and economic trends are considered in the context of a finite planet. In this view, trends in population, resource consumption and environmental degradation can be significant, or even dominant, determinants of the options available to human societies. A well-known, early example of this genre is the *Limits to Growth* study, sponsored by the Club of Rome, which modeled world trends by using systems dynamics.<sup>10</sup> A more recent example is the work of the Global Scenario group, convened by the Stockholm Environment Institute (SEI).<sup>11</sup> This work was informed by systems-dynamics thinking, but focused on identifying the qualitative characteristics of possible future worldwide scenarios for human civilization. SEI identified three types of scenario, with two variants of each type, as shown in Table 2-2. The Conventional Worlds scenario has Market Forces and Policy Reform variants, the Barbarization scenario has Breakdown and Fortress World variants, while the Great Transitions scenario has Eco-Communalism and New Sustainability Paradigm variants.

The SEI scenarios provide a useful framework for considering the paths that human civilization could follow during the next century and beyond. Not all paths are possible. Notably, continued trends of resource depletion and irreversible degradation of ecosystems would limit the range of options available to succeeding generations.

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<sup>8</sup> Marshall and Gurr, 2005.

<sup>9</sup> Kugler, 1995.

<sup>10</sup> Meadows et al, 1972.

<sup>11</sup> Raskin et al, 2002.

Similarly, destruction of human and industrial capital through large-scale warfare could inhibit economic and social recovery for many generations.

At present, the dominant world paradigm corresponds to the Market Forces scenario. Policy Reform is pursued at the rhetorical level, but is weakly implemented in practice. In parts of the world, notably in Africa, the Breakdown scenario is already operative. Aspects of the Fortress World scenario are also evident, and are likely to become more prominent if trends of resource depletion and ecosystem degradation continue, especially if major powers reject the dictates of sustainability and use armed force to secure resources. One sign of resource depletion is a growing body of analysis that predicts a peak in world oil production within the next few decades.<sup>12</sup> This prediction is sobering in view of the prominent role played by oil in the origins and conduct of war in the 20th century.<sup>13</sup> A now-familiar sign of ecosystem degradation is anthropogenic, global climate change. Analysts are considering the potential for climate change to promote, through its adverse impacts, social disorder and violence.<sup>14</sup> Other manifestations of ecosystem degradation are also significant. The recent Millennium Ecosystem Assessment determined that 15 out of the 24 ecosystem services that it examined "are being degraded or used unsustainably, including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards, and pests".<sup>15</sup> According to analysts at the United Nations University in Bonn, continuation of such trends could create up to 50 million environmental refugees by the end of the decade.<sup>16</sup>

At present, human population and material consumption per capita are growing to a degree that visibly stresses the biosphere. Moreover, ecosystem degradation and resource depletion coexist with economic inequality, increasing availability of sophisticated weapons technology, and an immature system of global governance. Major powers are doing little to address these problems. It seems unlikely that these imbalances and sources of instability will persist at such a scale during the remainder of the 21st century without major change occurring. That change could take various forms, but two broad-brush scenarios can illustrate the range of possible outcomes. In one scenario, there would be a transition to a civilization similar to the New Sustainability Paradigm articulated by SEI. That civilization would be comparatively peaceful and technologically sophisticated. Alternatively, the world could descend into a form of barbarism such as the Fortress World scenario articulated by SEI. That society might be locally prosperous, within enclaves, but would be violent and unstable.

In considering the level of security that should be built into an ISFSI, it would be prudent to adopt a pessimistic assumption of the potential for violent conflict in the future. Using SEI terminology, one could assume a Fortress World scenario with a high incidence of

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<sup>12</sup> Hirsch et al, 2005; GAO, 2007.

<sup>13</sup> Yergin, 1991.

<sup>14</sup> Gilman et al, 2007.

<sup>15</sup> MEA, 2005, page 1.

<sup>16</sup> Adam, 2005.

violent conflict of a type that involves sophisticated weapons and tactics. Violence might be perpetrated by national governments or by sub-national groups. A RAND corporation analyst has contemplated such a future in the following terms:<sup>17</sup>

"A dangerous world may offer an insidious combination of nineteenth-century politics, twentieth-century passions, and twenty-first century technology: an explosive mixture of multipolarity, nationalism, and advanced technology."

## **2.2 National Policy and Practice on Homeland Security**

To mount an effective response to the general threat environment for the US homeland, the nation needs a coherent homeland-security strategy that links responses to an array of specific threats, such as the potential for a deliberate attack on a commercial nuclear facility. As discussed below, there are deficiencies in the strategy that has actually been implemented. The nominal strategy was articulated by the White House in the *National Strategy for Homeland Security*, which was published in July 2002, and that guidance document apparently remains operative. The document sets forth three strategic objectives, in order of priority:<sup>18</sup>

- Prevent terrorist attacks within the United States;
- Reduce America's vulnerability to terrorism; and
- Minimize the damage and recover from attacks that do occur."

In pursuit of those objectives, the *National Strategy for Homeland Security* identifies six major mission areas: (i) intelligence and warning; (ii) border and transportation security; (iii) domestic counterterrorism; (iv) protecting critical infrastructure; (v) defending against catastrophic terrorism; and (vi) emergency preparedness and response. The fourth of those mission areas is highly relevant to nuclear reactors, spent-fuel pools, and ISFSIs, which are important elements of the nation's critical infrastructure. The other five mission areas are also relevant to nuclear facilities in various ways.

### *Protecting critical infrastructure*

The US Department of Homeland Security has issued the *National Infrastructure Protection Plan* (NIPP), whose purpose is to provide "the unifying structure for the integration of critical infrastructure and key resources (CI/KR) protection into a single national program".<sup>19</sup> Other federal agencies, including the NRC, have confirmed their acceptance of the NIPP.

The NIPP identifies three purposes of measures to protect critical infrastructure and key resources: (i) deter the threat; (ii) mitigate vulnerabilities; and (iii) minimize

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<sup>17</sup> Kugler, 1995, page 279.

<sup>18</sup> White House, 2002, page vii.

<sup>19</sup> DHS, 2006, page iii.

consequences associated with an attack or other incident. The NIPP identifies a range of protective measures as follows:<sup>20</sup>

"Protection can include a wide range of activities such as improving business protocols, hardening facilities, building resiliency and redundancy, incorporating hazard resistance into initial facility design, initiating active or passive countermeasures, installing security systems, leveraging "self-healing" technologies, promoting workforce surety programs, or implementing cyber security measures, among various others".

Protective measures of these types could significantly reduce the probability that an attack would be successful. Such measures could, therefore, "deter" attacks by altering attackers' cost-benefit calculations. That form of deterrence is different from deterrence attributable to an attacked party's capability to counter-attack. For convenience, the two forms of deterrence are described hereafter as "protective deterrence" and "counter-attack deterrence". It should be noted that the effective functioning of both forms of deterrence requires that: (i) potential attackers are aware of the deterrence strategy; and (ii) the deterrence strategy is technically credible. That requirement means that the existence and capabilities of protective measures, such as those identified in the NIPP, should be widely advertised. The technical details of a protective measure should, however, remain confidential if disclosure of those details would allow the measure to be defeated.

From the statement quoted above, it is clear that the authors of the NIPP recognize the potential benefits of designing protective measures into a facility before it is constructed. At the design stage, attributes such as resiliency, redundancy, hardening and passive operation can often be incorporated into a facility at a comparatively low incremental cost. Capturing opportunities for low-cost enhancement of protective measures would allow decision makers to design against a more pessimistic (i.e., more prudent) threat assumption, thereby strengthening protective deterrence, reducing the costs of other security functions (e.g., guard forces), and enhancing civil liberties (e.g., by reducing the perceived need for measures such as wiretapping). Moreover, incorporation of enhanced protective measures would often reduce risks associated with conventional accidents (e.g., fires), extreme natural events (e.g., earthquakes), or other challenges not directly attributable to human malice.

*Protective deterrence as part of a balanced policy for homeland security*

As mentioned in Section 2.1, above, reducing the risks of attack by sub-national groups requires a sophisticated, multi-faceted and sustained policy. The policy must balance multiple factors operating within and beyond the homeland. An unbalanced policy can be ineffective or counterproductive.

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<sup>20</sup> DHS, 2006, page 7.

A high-level task force convened by the Council on Foreign Relations (CFR) in 2002 understood the need for a balanced policy for homeland security.<sup>21</sup> One of the task force's major conclusions recognized the value of protective deterrence, while also recognizing that offensive military operations by the US could increase the risk of attack on the US. The conclusion was as follows:<sup>22</sup>

*"Homeland security measures have deterrence value: US counterterrorism initiatives abroad can be reinforced by making the US homeland a less tempting target. We can transform the calculations of would-be terrorists by elevating the risk that (1) an attack on the United States will fail, and (2) the disruptive consequences of a successful attack will be minimal. It is especially critical that we bolster this deterrent now since an inevitable consequence of the US government's stepped-up military and diplomatic exertions will be to elevate the incentive to strike back before these efforts have their desired effect."*

The NIPP could support a vigorous national program of protective deterrence, as recommended by the CFR task force in 2002. However, current priorities of the US government are not consistent with such a program. Resources and attention devoted to offensive military operations are much larger than those devoted to the protection of critical infrastructure.<sup>23</sup> The White House states, in the *National Strategy for Combating Terrorism*, issued in September 2006:<sup>24</sup> "We have broken old orthodoxies that once confined our counterterrorism efforts primarily to the criminal justice domain." In practice, that statement means that the US government relies overwhelmingly on military means to reduce the risks of attacks on US assets by sub-national groups. That policy continues despite mounting evidence, as illustrated by Table 2-1, that it is unbalanced and counterproductive.

A well-informed analyst of homeland security summarizes current national priorities in the following statement:<sup>25</sup>

*"Since the White House has chosen to combat terrorism as essentially a military and intelligence activity, it treats homeland security as a decidedly second-rate priority. The job of everyday citizens is to just go about their lives, shopping and traveling, while the Pentagon, Central Intelligence Agency, and National Security Agency wage the war."*

During a future Presidential administration, national priorities may shift, leading to greater emphasis on protective deterrence. Unfortunately, critical-infrastructure facilities

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<sup>21</sup> Members of the task force included two former Secretaries of State, two former chairs of the Joint Chiefs of Staff, a former Director of the CIA and the FBI, two former US Senators, and other eminent persons.

<sup>22</sup> Hart et al, 2002, pp 14-15.

<sup>23</sup> Flynn, 2007.

<sup>24</sup> White House, 2006, page 1.

<sup>25</sup> Flynn, 2007, page 11.

constructed prior to that policy shift may lack the protective design features that are envisioned in the NIPP. Persons responsible for the design of currently-proposed facilities, such as the proposed ISFSI at Diablo Canyon, could anticipate a national policy shift and take design decisions accordingly.

Table 2-3 illustrates the options and issues that should be considered in developing a balanced policy for protecting US critical infrastructure from attack by sub-national groups. This illustrative table shows the potential benefits that could be gained by assigning a higher priority to protective deterrence.

### **2.3 Commercial Nuclear Facilities as Potential Targets of Attack**

The *National Strategy for Combating Terrorism* discusses the importance of protecting critical infrastructure and key resources. Potential targets in this category are described as: "systems and assets so vital that their destruction or incapacitation would have a debilitating effect on the security of our Nation". In listing targets in this category, the Strategy includes: "nuclear reactors, materials, and waste".<sup>26</sup> An ISFSI at Diablo Canyon would clearly fit within that class of targets.

A sub-national group contemplating an attack within the US homeland would have a wide choice of targets. Also, groups in that category could vary widely in terms of their capabilities and motivations. In the context of potential attacks on nuclear facilities, the groups of concern are those that are comparatively sophisticated in their approach and comparatively well provided with funds and skills. The group that attacked New York and Washington in September 2001 met this description. A group of this type could choose to attack a US nuclear facility for one or both of two broad reasons. First, the attack could be highly symbolic. Second, the impacts of the attack could be severe.

#### *Nuclear facilities as symbolic targets*

From the symbolic perspective, commercial nuclear facilities are inevitably associated with nuclear weapons. The association further extends to the United States' large and technically sophisticated capability for offensive military operations. Application of that capability has aroused resentment in many parts of the world. Although nuclear weapons have not been used by the United States since 1945, US political leaders have repeatedly threatened, implicitly or explicitly, to use nuclear weapons again. Those threats coexist with efforts to deny nuclear weapons to other countries. The US government justified its March 2003 invasion of Iraq in large part by the possibility that the Iraqi government might eventually deploy nuclear weapons. There is speculation that the United States will attack nominally commercial nuclear facilities in Iran to forestall Iran's deployment of nuclear weapons.<sup>27</sup> Yet, the US government rejects the constraint of its own nuclear weapons by international agreements such as the Non-Proliferation Treaty.<sup>28</sup> As an

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<sup>26</sup> White House, 2006, page 13.

<sup>27</sup> Hersh, 2006; Brzezinski, 2007.

<sup>28</sup> Deller, 2002; Scarry, 2002; Franceschini and Schaper, 2006.

approach to international security, this policy has been criticized by the director general of the International Atomic Energy Agency as "unsustainable and counterproductive".<sup>29</sup> It would be prudent to assume that this policy will motivate sub-national groups to respond asymmetrically to US nuclear superiority, possibly through an attack on a US commercial nuclear facility.

*Radiological impacts of an attack on a nuclear facility*

The impacts of an attack on a commercial nuclear facility could be severe because these facilities typically contain large amounts of radioactive material. Release of this material to the environment could create a variety of severe impacts. Also, as explained in Section 2.4, below, US nuclear facilities are provided with a defense that is "light" in a military sense. Moreover, imprudent design choices have made a number of these facilities highly vulnerable to attack. That combination of factors means that many US nuclear facilities can be regarded as potent radiological weapons that await activation by an enemy.

Nuclear facilities contain a variety of radioactive isotopes, but one isotope, namely cesium-137, is especially useful as an indicator of the potential for radiological harm. Cesium-137 is a radioactive isotope with a half-life of 30 years. This isotope accounts for most of the offsite radiation exposure that is attributable to the 1986 Chernobyl reactor accident, and for about half of the radiation exposure that is attributable to fallout from the testing of nuclear weapons in the atmosphere.<sup>30</sup> Cesium is a volatile element that would be liberally released during conventional accidents or attack scenarios that involve overheating of nuclear fuel.

Table 2-4 shows estimated amounts of cesium-137 in nuclear fuel in the Diablo Canyon reactors and spent-fuel pools, and in one of the spent-fuel storage modules of the proposed Diablo Canyon ISFSI. Table 2-5 compares these amounts with atmospheric releases of cesium-137 from detonation of a 10-kilotonne fission weapon, the Chernobyl reactor accident of 1986, and atmospheric testing of nuclear weapons. These data indicate that release of a substantial fraction of the cesium-137 in a Diablo Canyon nuclear facility could create comparatively large radiological impacts.

*Land contamination by cesium-137*

The radiological impacts of an atmospheric release of cesium-137 arise primarily from land contamination. Small particles containing cesium-137 are deposited on soil, vegetation and buildings. These particles emit gamma radiation that affects people who travel through or reside in the contaminated area. Food and water supplies also become contaminated. Over time, the amount of deposited cesium-137 is reduced through radioactive decay (with a half-life of 30 years) and through natural processes

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<sup>29</sup> ElBaradei, 2004, page 9.

<sup>30</sup> DOE, 1987.

(weathering) that carry cesium deeper into soil or into streams and lakes where it is deposited in sediments.

One measure of the radiological impacts attributable to deposition of cesium-137 is the area of land that would become uninhabitable. For illustration, assume that the threshold of uninhabitability is an external, whole-body dose of 10 rem over 30 years. That level of radiation exposure, which would represent about a three-fold increase above the typical level of background (natural) radiation, was used in the NRC's 1975 *Reactor Safety Study* as a criterion for relocating populations from rural areas.<sup>31</sup>

A radiation dose of 10 rem over 30 years corresponds to an average dose rate of 0.33 rem per year.<sup>32</sup> The health effects of radiation exposure at this dose level have been estimated by the National Research Council's Committee on the Biological Effects of Ionizing Radiations (BEIR V committee).<sup>33</sup> The committee estimated that a continuous lifetime exposure of 0.1 rem per year would increase the incidence of fatal cancers in an exposed population by 2.5 percent for males and 3.4 percent for females.<sup>34</sup> Incidence would scale linearly with dose, in this low-dose region.<sup>35</sup> Thus, an average lifetime exposure of 0.33 rem per year would increase the incidence of fatal cancers by about 8 percent for males and 11 percent for females. About 21 percent of males and 18 percent of females normally die of cancer.<sup>36</sup> In other words, in populations residing continuously at the threshold of uninhabitability (an external dose rate of 0.33 rem per year), about 2 percent of people would suffer a fatal cancer that would not otherwise occur.<sup>37</sup> Internal doses from contaminated food and water could cause additional cancer fatalities.

An average dose rate of 0.33 rem per year would be experienced at the boundary of the uninhabitable area. Within that area, the external dose rate from cesium-137 would exceed the threshold of 10 rem over 30 years. At some locations, the dose rate could exceed this threshold by orders of magnitude. Therefore, persons choosing to live within the uninhabitable area could experience an incidence of fatal cancers at a level higher than is set forth above.

For a postulated release of cesium-137 to the atmosphere, the area of uninhabitable land can be estimated from calculations done by Jan Beyea.<sup>38</sup> Two releases of cesium-137 are

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<sup>31</sup> NRC, 1975, Appendix VI, page 11-17.

<sup>32</sup> At a given location contaminated by cesium-137, the resulting external, whole-body dose received by a person at that location would decline over time, due to radioactive decay and weathering of the cesium-137. Thus, a person receiving 10 rem over an initial 30-year period would receive a lower dose over the subsequent 30-year period.

<sup>33</sup> National Research Council, 1990.

<sup>34</sup> National Research Council, 1990, Table 4-2.

<sup>35</sup> The BEIR V committee assumed a linear dose-response model for cancers other than leukemia, and a model for leukemia that is effectively linear in the low-dose range. See: National Research Council, 1990, pp 171-176.

<sup>36</sup> National Research Council, 1990, Table 4-2.

<sup>37</sup> For males,  $0.08 \times 0.21 = 0.017$ . For females,  $0.11 \times 0.18 = 0.020$ .

<sup>38</sup> Beyea, 1979. Related calculations are provided in: Alvarez et al, 2003; Beyea et al, 2004.

postulated here, drawing upon data from Table 2-4. The first release is 30 million Curies, representing about one-half of the cesium-137 in a Diablo Canyon spent-fuel pool. The second postulated release is 3 million Curies, representing about one-half of the cesium-137 in the core of a Diablo Canyon reactor, or about one-half of the cesium-137 in four spent-fuel storage modules of a Diablo Canyon ISFSI. For typical weather conditions, a release of 30 million Curies of cesium-137 would render about 75,000 square kilometers of land uninhabitable, assuming that the radioactive plume travels inland rather than out to sea. A release of 3 million Curies would render uninhabitable about 7,500 square kilometers.

An atmospheric release of 50 percent of the cesium-137 in a Diablo Canyon spent-fuel pool would be a likely outcome of a conventional accident or attack that causes the water level in the pool to fall below the top of the fuel-storage racks.<sup>39</sup> Similarly, a release of 50 percent of the cesium-137 in a Diablo Canyon reactor would be a likely outcome of a range of potential accidents or attacks that affect the reactor. This report focuses on the Diablo Canyon ISFSI rather than the reactors and spent-fuel pools. The potential release of cesium-137 from the Diablo Canyon ISFSI is addressed in Section 4, below.

#### **2.4 The NRC's Approach to Nuclear-Facility Security**

A policy on protecting nuclear facilities from attack is laid down in NRC regulation 10 CFR 50.13. That regulation was promulgated in September 1967 by the US Atomic Energy Commission (AEC) – which preceded the NRC – and was upheld by the US Court of Appeals in August 1968. It states:<sup>40</sup>

"An applicant for a license to construct and operate a production or utilization facility, or for an amendment to such license, is not required to provide for design features or other measures for the specific purpose of protection against the effects of (a) attacks and destructive acts, including sabotage, directed against the facility by an enemy of the United States, whether a foreign government or other person, or (b) use or deployment of weapons incident to US defense activities."

Some readers might interpret 10 CFR 50.13 to mean that licensees are not required to design or operate nuclear facilities to resist potential attacks by sub-national groups. The NRC has rejected that interpretation in the context of vehicle-bomb attacks, stating:<sup>41</sup>

"It is simply not the case that a vehicle bomb attack on a nuclear power plant would almost certainly represent an attack by an enemy of the United States, within the meaning of that phrase in 10 CFR 50.13."

Events have obliged the NRC to progressively require greater protection against attacks by sub-national groups. A series of events, including the 1993 vehicle-bomb attack on

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<sup>39</sup> Alvarez et al, 2003; Thompson, 2006; National Research Council, 2006.

<sup>40</sup> Federal Register, Vol. 32, 26 September 1967, page 13445.

<sup>41</sup> NRC, 1994, page 38893.

the World Trade Center in New York, persuaded the NRC to introduce, in 1994, regulatory amendments requiring licensees to defend nuclear power plants against vehicle bombs.<sup>42</sup> The attacks on New York and Washington in September 2001 led the NRC to require additional protective measures.

With rare exceptions, the NRC has refused to consider potential malicious actions in the context of license proceedings or environmental impact statements. The NRC's policy on this matter is illustrated by a September 1982 ruling by the Atomic Safety and Licensing Board (ASLB) in the operating-license proceeding for the Harris nuclear power plant. An intervenor, Wells Eddleman, had proffered a contention alleging, in part, that the plant's safety analysis was deficient because it did not consider the "consequences of terrorists commandeering a very large airplane.....and diving it into the containment." In refusing to consider this contention, the ASLB stated:<sup>43</sup>

"This part of the contention is barred by 10 CFR 50.13. This rule must be read *in pari materia* with 10 CFR 73.1(a)(1), which describes the "design basis threat" against which commercial power reactors *are* required to be protected. Under that provision, a plant's security plan must be designed to cope with a violent external assault by "several persons," equipped with light, portable weapons, such as hand-held automatic weapons, explosives, incapacitating agents, and the like. Read in the light of section 73.1, the principal thrust of section 50.13 is that military style attacks with heavier weapons are not a part of the design basis threat for commercial reactors. Reactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost. Thus Applicants are not required to design against such things as artillery bombardments, missiles with nuclear warheads, or kamikaze dives by large airplanes, despite the fact that such attacks would damage and may well destroy a commercial reactor."

#### *The design basis threat*

The NRC requires its licensees to defend against a design basis threat (DBT), a postulated attack that has become more severe over time. The present DBT for nuclear power plants was promulgated in January 2007. Details are not publicly available. (The NRC publishes a summary description, which is provided below.) The present DBT is similar to one ordered by the NRC in April 2003.<sup>44</sup> At that time, the NRC described its order as follows:<sup>45</sup>

"The Order that imposes revisions to the Design Basis Threat requires power plants to implement additional protective actions to protect against sabotage by terrorists and other adversaries. The details of the design basis threat are

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<sup>42</sup> NRC, 1994.

<sup>43</sup> ASLB, 1982.

<sup>44</sup> NRC Press Release No. 07-012, 29 January 2007.

<sup>45</sup> NRC Press Release No. 03-053, 29 April 2003.

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safeguards information pursuant to Section 147 of the Atomic Energy Act and will not be released to the public. This Order builds on the changes made by the Commission's February 25, 2002 Order. The Commission believes that this DBT represents the largest reasonable threat against which a regulated private security force should be expected to defend under existing law."

From that statement, and from other published information, it is evident that the NRC requires a comparatively "light" defense for nuclear power plants and their spent fuel. The scope of the defense does not reflect a full spectrum of threats. Instead, it reflects a consensus about the level of threat that licensees can "reasonably" be expected to resist.<sup>46</sup> In illustration of this approach, when the NRC adopted the currently-applicable DBT rule in January 2007, it stated that the rule "does not require protection against a deliberate hit by a large aircraft", and that "active protection [of nuclear power plants] against airborne threats is addressed by other federal organizations, including the military".<sup>47</sup>

The present DBT for "radiological sabotage" at a nuclear power plant has the following published attributes:<sup>48</sup>

"(i) A determined violent external assault, attack by stealth, or deceptive actions, including diversionary actions, by an adversary force capable of operating in each of the following modes: A single group attacking through one entry point, multiple groups attacking through multiple entry points, a combination of one or more groups and one or more individuals attacking through multiple entry points, or individuals attacking through separate entry points, with the following attributes, assistance and equipment:

- (A) Well-trained (including military training and skills) and dedicated individuals, willing to kill or be killed, with sufficient knowledge to identify specific equipment or locations necessary for a successful attack;
- (B) Active (e.g., facilitate entrance and exit, disable alarms and communications, participate in violent attack) or passive (e.g., provide information), or both, knowledgeable inside assistance;
- (C) Suitable weapons, including handheld automatic weapons, equipped with silencers and having effective long range accuracy;
- (D) Hand-carried equipment, including incapacitating agents and explosives for use as tools of entry or for otherwise destroying reactor, facility, transporter, or container integrity or features of the safeguards system; and
- (E) Land and water vehicles, which could be used for transporting personnel and their hand-carried equipment to the proximity of vital areas; and

<sup>46</sup> Fertel, 2006; Wells, 2006; Brian, 2006.

<sup>47</sup> NRC Press Release No. 07-012, 29 January 2007.

<sup>48</sup> 10 CFR 73.1 Purpose and scope, accessed from the NRC web site ([www.nrc.gov](http://www.nrc.gov)) on 14 June 2007.

- (ii) An internal threat; and
- (iii) A land vehicle bomb assault, which may be coordinated with an external assault; and
- (iv) A waterborne vehicle bomb assault, which may be coordinated with an external assault; and
- (v) A cyber attack."

That DBT seems impressive, and is more demanding than previously-published DBTs. However, the DBT cannot be highly demanding in practice, given the equipment that the NRC requires for a security force. Major items of required equipment are semiautomatic rifles, shotguns, semiautomatic pistols, bullet-resistant vests, gas masks, and flares for night vision.<sup>49</sup> Plausible attacks could overwhelm a security force equipped in this manner. Also, press reports state that the assumed attacking force contains no more than six persons.<sup>50</sup>

Table 2-6 sets forth some potential modes and instruments of attack on a nuclear power plant, and summarizes the present defenses against these modes and instruments. That table shows that a variety of potential attack scenarios could not be effectively resisted by present defenses. Potential attacks on an ISFSI are discussed in Section 4, below.

#### *Protective deterrence and the NRC*

A rationale for the present level of protection of nuclear facilities was articulated by the NRC chair, Richard Meserve, in 2002:<sup>51</sup>

"If we allow terrorist threats to determine what we build and what we operate, we will retreat into the past – back to an era without suspension bridges, harbor tunnels, stadiums, or hydroelectric dams, let alone skyscrapers, liquid-natural-gas terminals, chemical factories, or nuclear power plants. We cannot eliminate the terrorists' targets, but instead we must eliminate the terrorists themselves. A strategy of risk avoidance – the elimination of the threat by the elimination of potential targets – does not reflect a sound response."

That statement shows no understanding of the need for a balanced policy to protect critical infrastructure, employing the principles of protective deterrence. There is considerable potential to embody those principles in the design of nuclear facilities, especially new facilities. It has been known for decades that nuclear power plants could be designed to be more robust against attack. For example, in the early 1980s the reactor vendor ASEA-Atom developed a preliminary design for an "intrinsically safe" commercial reactor known as the PIUS reactor. Passive-safety design principles were

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<sup>49</sup> 10 CFR 73 Appendix B – General Criteria for Security Personnel, Section V, accessed from the NRC web site ([www.nrc.gov](http://www.nrc.gov)) on 14 June 2007.

<sup>50</sup> Hebert, 2007.

<sup>51</sup> Meserve, 2002, page 22.

used. The design basis for the PIUS reactor included events such as equipment failures, operator errors and earthquakes, but also included: (i) takeover of the plant for one operating shift by knowledgeable saboteurs equipped with large amounts of explosives; (ii) aerial bombardment with 1,000-pound bombs; and (iii) abandonment of the plant by the operators for one week.<sup>52</sup> An ISFSI could be designed to withstand similar threats.

*Consideration of malicious actions in environmental impact statements*

As stated above, the NRC has generally refused to consider potential malicious actions in environmental impact statements. An exception is the NRC's August 1979 *Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel* (NUREG-0575), which considered potential sabotage events at a spent-fuel pool.<sup>53</sup> Table 2-7 describes the postulated events, which encompassed the detonation of explosive charges in the pool, breaching of the walls of the pool building and the pool floor by explosive charges or other means, and takeover of the central control room for one half-hour. Involvement of up to about 80 adversaries was implied.

NUREG-0575 did not recognize the potential for an attack with these attributes to cause a fire in the pool.<sup>54</sup> Technically-informed attackers operating within this envelope of attributes could cause a fire in a spent-fuel pool at Diablo Canyon or any other operating nuclear power plant in the US.<sup>55</sup> Informed attackers could use explosives, and their command of the control room for one half-hour, to drain water from the pool and release radioactive material from the adjacent reactor. The radiation field from the reactor release and the drained pool could preclude personnel access, thus precluding recovery actions if command of the plant were returned to the operators after one half-hour. Exposure of spent fuel to air would initiate a fire that would release to the atmosphere a large fraction of the pool's inventory of cesium-137.<sup>56</sup>

### **3. An Appropriate Framework for Assessing the Risks of Malicious Actions at Nuclear Facilities**

#### **3.1 Extending Traditional Risk Assessment to Encompass Malicious Actions**

Over a three-decade period, the NRC has accepted, in various contexts, that an analysis of a nuclear facility's environmental impacts should consider a range of conventional accidents. Here, the term "conventional accidents" refers to incidents caused by human error, equipment failure or natural events, but excludes incidents caused by malicious actions. The radiological impacts of conventional accidents are examined through the

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<sup>52</sup> Hannerz, 1983.

<sup>53</sup> NRC, 1979, Section 5 and Appendix J.

<sup>54</sup> The sabotage events postulated in NUREG-0575 yielded comparatively small radioactive releases.

<sup>55</sup> Spent-fuel pools at Diablo Canyon and other US nuclear power plants are currently equipped with high-density racks for holding spent fuel. Loss of water from a pool equipped with high-density racks would, over a wide range of water-loss scenarios, lead to ignition and burning of spent fuel assemblies.

<sup>56</sup> Alvarez et al, 2003; Thompson, 2006; National Research Council, 2006.

use of risk-assessment tools such as probabilistic risk assessment (PRA). The first PRA for a commercial nuclear reactor was the *Reactor Safety Study*.<sup>57</sup> A PRA for a nuclear facility considers a number of conventional accident scenarios, estimating both their radiological consequences and their probabilities of occurrence. In a competently-conducted PRA study, a conventional accident scenario is not screened out a priori if its probability is thought to be low. Instead, the scenario's radiological consequences and probability are systematically estimated to determine its contribution to the overall risks associated with the facility.

The traditional tools and practices of radiological risk assessment should be adapted to address the risks of malicious actions at a nuclear facility. In this application of risk assessment, conventional accident scenarios would be replaced by attack scenarios. (These are also known as threat scenarios.) Probability would be treated differently in this application, however, because there is usually no statistical basis to support quantitative estimates of the probabilities of malicious actions. To accommodate that problem, occurrence of a representative set of malicious actions would be assumed. The scenarios flowing from each postulated malicious action would then be analyzed to estimate the conditional probabilities and other characteristics of the outcomes, including radiological impacts. The resulting information would be useful for a variety of purposes. It would, for example, help to identify options to reduce the risks of malicious actions through changes in the design or mode of operation of the facility. PRA-related studies have been very helpful in this respect in the context of conventional accidents.

Information obtained by assuming the occurrence of a set of malicious actions should be combined with qualitative estimates of the probabilities of the malicious actions, to yield risk findings that have qualitative and quantitative components. The process of combination should occur in such a way that assumptions and qualitative estimates of probability can be re-visited at any time. With that provision, new information or differing professional opinions could be factored into the risk findings without difficulty. A standardized terminology should be developed to facilitate reasoned discussion of assumptions and qualitative estimates.

The NRC, in developing its 1994 ruling on protection of nuclear power plants against vehicle bombs, adopted the PRA-adaptation approach described above, stating:<sup>58</sup>

"The NRC does not believe that it can quantify the likelihood of vehicle bomb attack. However, it has performed a conditional probabilistic risk analysis for an existing power reactor site, assuming an attempt to damage a nuclear power plant with a design basis vehicle bomb placed at locations within the protected area that would create the greatest risk to public health and safety. The analysis indicated that the contribution to core damage frequency could be high."

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<sup>57</sup> NRC, 1975.

<sup>58</sup> NRC, 1994, page 38891.

The NRC argued that its vehicle-bomb ruling was "prudent" in view of a vehicle intrusion incident at the Three Mile Island site and a vehicle bombing of the World Trade Center in February 1993.<sup>59</sup> In support of this view, the NRC noted that the 1993 World Trade Center bombing was "organized within the United States and implemented with materials obtained on the open market in the United States".<sup>60</sup>

The vehicle-bomb ruling was a step forward in that the NRC recognized one form of threat scenario (use of a vehicle bomb) for an attack on a nuclear facility by a sub-national group. However, the NRC failed to recognize other threat scenarios that are at least as credible. Section 4.3, below, discusses other, credible scenarios in the context of an ISFSI; analogous scenarios are relevant to power reactors and spent-fuel pools. Also, the NRC failed to develop a standardized terminology for assumptions and qualitative estimates regarding the probabilities of attack scenarios. At present (June 2007), the NRC still lacks such a terminology.

Assessment of malice-related risks, as described here, would typically involve the use of sensitive information. Here, the term "sensitive" refers to detailed information that could substantially assist an attacking group to attain its objectives. Management of sensitive information is discussed in Section 3.3, below.

In reviewing a license application for a nuclear facility, the NRC considers a set of design-basis conventional accidents. That consideration occurs under the umbrella of the Atomic Energy Act. An analogous situation pertains in the security realm. There, the NRC considers a facility's ability to withstand a design-basis threat. That consideration also occurs under the umbrella of the Atomic Energy Act. However, when the NRC examines a facility's environmental impacts, it does so under the umbrella of NEPA. In performing such examinations, the NRC has repeatedly accepted that it should consider conventional accidents more severe than design-basis conventional accidents. Logic indicates, therefore, that an assessment by the NRC of the risks of malicious actions at a nuclear facility, conducted under the umbrella of NEPA, should consider reasonably foreseeable threats more severe than design-basis threats.

### **3.2 Examining a Full Range of Risks, Risk-Reducing Options and their Implications**

A competently-performed assessment of the conventional accident risks at a nuclear facility would consider radiological risks. The assessment would also identify and characterize options for reducing those risks by modifying the facility's design or mode of operation. Articulating knowledge about such options is an important purpose of NEPA. Essentially the same requirements should apply to an assessment of the risks of malicious actions. The latter assessment should consider radiological risks and options for reducing those risks.

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<sup>59</sup> NRC, 1994, Summary.

<sup>60</sup> NRC, 1994, page 38891.

*Additional risks and impacts*

Risks and impacts arising from the potential for malicious actions are not limited to radiological risks. Social and economic impacts could be caused by malicious actions, the expectation of malicious actions, the choice of design options, or other factors. The term "additional risks and impacts" is used here to encompass the potential for such impacts. These additional risks and impacts deserve careful research, and it is premature to provide a taxonomy of them. Additional risks and impacts, and their relationships with risk-reducing options, should be examined in any malice-related risk assessment. The following, simplified example illustrates some additional risks and impacts, and shows the importance of considering them in a risk assessment.

Consider a proposed nuclear facility (e.g., a reactor, a spent-fuel pool, or an ISFSI) that would contain a large amount of radioactive material. There are two design options. Option A would employ a design that was developed one or more decades ago. It would have a comparatively low ability to resist an attack. To compensate for its vulnerability, it would be protected by a large force of armed guards. Detailed information about the option's design, and about the guard force, would be secret. The public would be excluded from any effective role in the licensing of this option. Option B would employ a design using hardening, resiliency and passive protection as envisioned in the NIPP. It would have a comparatively high ability to resist an attack. As a result, a less capable guard force would be required, there would be no need for secrecy, and the public would have full access to license proceedings.

To further simplify this example, assume that the estimated life-cycle costs and radiological risks of Options A and B would be identical. In that case, Option A would be clearly inferior because it would increase the use of secret information and decrease the public's role in decision-making, tendencies that are antithetical to US traditions and inconsistent with long-term national prosperity. Put differently, Option A would have higher levels of social and economic impacts. Moreover, if a malicious action were to cause a release of radioactive material, the social and economic impacts could be higher if Option A had been chosen, because that choice would have relegated the public to a lesser role.

The preceding example, although simplified, is far from theoretical. Design options have been employed that are highly vulnerable to attack, and the NRC has become much more secretive in recent years. Consider the case of spent-fuel pools equipped with high-density racks. All the spent-fuel pools at US nuclear power plants are so equipped. The NRC asserts that these pools are adequately safe and secure. Yet, since September 2001 the NRC has not published any technical analysis on the safety and security of spent-fuel pools, and has denied requests by intervenors that spent-fuel-pool risks be addressed in evidentiary hearings. As a result, the NRC has never published any analysis on the risks of a spent-fuel-pool fire initiated by malicious action, and has never allowed an examination of these risks in a license proceeding. In this real-world case, spent-fuel

pools equipped with high-density racks are Option A. An Option B is available, namely re-equipping the pools with low-density, open-frame racks, as was intended when the present generation of US nuclear power plants was designed.<sup>61</sup>

#### *Cumulative risks of closely-associated facilities*

Many nuclear facilities are closely associated with other nuclear facilities. For example, the Diablo Canyon site features two reactors and two spent-fuel pools. These four facilities are in close physical proximity and share many supporting systems. As a result, the conventional accident risks and malice-related risks associated with any one of these four facilities can only be properly understood through analyses that consider interactions among all four facilities. The proposed ISFSI at Diablo Canyon would share the guard force and other security measures that are deployed at the site. A release of radioactive material from the ISFSI could affect the operation of the reactors and pools, and vice versa. Thus, malice-related risks at the ISFSI should be considered in the context of malice-related risks across the entire site. Also, the ISFSI would be used to support continued operation of the reactors. Thus, risks arising from operation of the ISFSI over its lifetime should be viewed in the context of reactor risks.

To generalize from the Diablo Canyon example, any assessment of conventional accident risks or malice-related risks should examine the interactions among closely-associated facilities, and should assess the cumulative risks arising from operation of those facilities.

### **3.3 Managing Sensitive Information**

A thorough assessment of malice-related risks at a nuclear facility would typically involve the use of sensitive information, defined here as detailed information that could substantially assist an attacking group to attain its objectives. Given this definition, general information about a nuclear facility, including its overall physical layout, operating principles and radioactive inventory, would not be sensitive. Information about the potential radiological impacts of a malicious action would not be sensitive. Detailed information about vulnerable points of the facility, or detailed information about attack scenarios that could exploit such points of vulnerability, could be sensitive. None of the information provided in this report is sensitive.

Sensitive information, as defined here, is not appropriate for general dissemination. Thus, processes for the assessment of malice-related risks must involve rules and practices for managing sensitive information so that its distribution is limited.

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<sup>61</sup> In this case, Option B would have a much lower radiological risk than Option A, but a higher capital cost.

*The costs of secrecy*

Rules and practices for designating information as sensitive, and for managing information so designated, should recognize that secrecy has high costs. As stated in Section 3.2, above, secrecy is antithetical to US traditions and inconsistent with long-term national prosperity. Thus, an assessment of malice-related risks at a nuclear facility should consider the social and economic impacts of secrecy. That consideration would tend to favor design options involving features such as hardening, resiliency and passive protection. In some instances, secrecy-related impacts could be so high that they outweigh any benefits from operating a nuclear facility. It should be remembered that nuclear facilities exist to serve society, rather than vice versa.

It should also be noted that the safety and security of nuclear facilities will be significantly and adversely affected by an entrenched culture of secrecy. Such a culture is not compatible with a clear-headed, science-based approach to the understanding of risks. Entrenched secrecy perpetuates dogma, stifles dissent, and can create a false sense of security. In illustration, the culture of secrecy in the former USSR was a major factor contributing to the occurrence of the 1986 Chernobyl reactor accident.<sup>62</sup>

*The limited effectiveness of knowledge suppression*

Within the NRC and elsewhere, factions will argue that suppression of knowledge can reduce the risks of malicious actions at nuclear facilities. Knowledge suppression is, however, a strategy with limited effectiveness. Nuclear fission power is a mature technology based on science from the mid-20th century. Detailed information about nuclear technology and individual nuclear facilities is archived at many locations around the world, and large numbers of people have worked in nuclear facilities. Similarly, information about weapons and other devices that could be used to attack nuclear facilities is widely available. Large numbers of people have been trained to use such devices in a military context. Thus, it would be prudent to assume that sophisticated sub-national groups can identify and exploit vulnerabilities in US nuclear facilities.

*A balanced approach to managing sensitive information*

From the preceding discussion, it is clear that managing sensitive information should be done carefully, balancing several considerations. The NRC has not achieved this balance since September 2001. Instead, the NRC has taken a crude, counterproductive approach in which it is excessively secretive while also making assertions about safety and security that do not withstand critical examination. To help correct this situation, the NRC should engage public stakeholders (citizen groups, academics, state and local governments, etc.) and licensees in a dialogue that seeks consensus on an effective, balanced policy for

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<sup>62</sup> Thompson, 2002, Section X.

management of sensitive information. Implementation of that policy would not necessarily require changes in NRC rules.

### **3.4 Ensuring Compatibility with a Comprehensive National Strategy for Homeland Security**

Section 2, above, explains the need for a comprehensive, balanced strategy to reduce the risks of attack on US critical infrastructure by sub-national groups. The *National Infrastructure Protection Plan* could be a major element of that strategy, supporting a policy of enhanced protective deterrence.

The conduct of thorough assessments of malice-related risks at US nuclear facilities could make a major contribution to implementation of the NIPP. These assessments could provide models to be followed in other infrastructure sectors, such as the chemical industry. Even better, the NRC could work with other agencies to develop a risk-assessment framework that allows risks to be compared not only within an infrastructure sector (such as the nuclear industry, or the chemical industry) but also among sectors.

As an initial step, the NRC should develop malice-related risk assessments that are scientifically credible and meet the other requirements set forth above. While developing these assessments, the NRC should engage in dialogue and cooperative research with other agencies and stakeholders, seeking to develop a pan-sectoral risk-assessment framework.

### **3.5 Incorporating Findings into an Environmental Assessment or Environmental Impact Statement**

Sections 3.1 through 3.4, above, outline a set of standards for the conduct of malice-related risk assessments. When those assessments are done, they must be incorporated into EAs or EISs, either retroactively or concurrently. During that process, provision must be made for limiting the dissemination of sensitive information. The best approach would be to place sensitive information in appendices whose dissemination is limited. The full title of each such appendix, and a general summary of its purpose, scope and findings, should be included in the body of the EA or EIS, which would be openly published.

## **4. The NRC Staff's Supplement to the Environmental Assessment for the Diablo Canyon ISFSI**

### **4.1 Scope, Assumptions, Methodology and Conclusions of the Staff's Supplement**

In October 2003, the NRC Staff issued an Environmental Assessment for the proposed ISFSI at Diablo Canyon. Pursuant to a ruling by the 9th Circuit of the US Court of

Appeals, the Staff issued a Supplement to that EA in May 2007.<sup>63</sup> Here, that Supplement is described as the Diablo EA Supplement. The Supplement addresses the risks of potential malicious actions at the proposed ISFSI. It concludes (at page 7) that "a terrorist attack that would result in a significant release of radiation affecting the public is not reasonably expected to occur".

Shortly after issuing the Diablo EA Supplement, the NRC Staff issued an analogous document related to the application by Pa'ina Hawaii, LLC, to build and operate a commercial, pool-type industrial irradiator in Honolulu, Hawaii, at the Honolulu International Airport. That document is analogous to the Diablo EA Supplement because both respond to the same ruling by the 9th Circuit of the US Court of Appeals. The document takes the form of a Supplemental Appendix to the Staff's Draft EA for the proposed irradiator, which was issued in December 2006.<sup>64</sup> Hereafter, the Supplemental Appendix is described as the "Pa'ina EA Appendix".

This report focuses on issues related to the Diablo EA Supplement. However, the Pa'ina EA Appendix provides additional, relevant information, and is therefore briefly examined here.

The Diablo EA Supplement is a short (8-page) document. It claims (at page 1) to address "the environmental impacts from potential terrorist acts directed at the Diablo Canyon ISFSI". It mentions technical analyses related to potential malicious actions at the Diablo Canyon ISFSI, but does not itself provide such analyses. Nor does it cite any document that describes such analyses. It provides only a partial, incomplete view of its underlying assumptions and methodology. Thus, the Supplement's conclusions cannot be linked to a technical base of evidence and analysis.

#### *Defense of the Diablo Canyon ISFSI*

The Diablo EA Supplement provides (at page 4) a brief discussion of nation-wide security measures implemented by the US government since September 2001. That discussion focuses on measures intended to prevent persons with malicious intent from taking control of commercial aircraft used to carry passengers or cargo. There is no discussion of security measures in the context of smaller, general-aviation aircraft, despite the existence of a large US-based fleet of such aircraft and the potential for such an aircraft to be used, in an explosive-laden configuration, as an instrument of attack on a nuclear facility.

The Supplement goes on to provide (at pages 4 and 5) a discussion of the security measures that the NRC requires licensees to implement at ISFSIs and other nuclear facilities. Major security measures required at ISFSIs include: (i) physical barriers; (ii) surveillance; (iii) intrusion detection; (iv) a response to intrusions; and (v) offsite

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<sup>63</sup> NRC, 2007a.

<sup>64</sup> NRC, 2007b.

assistance from local law enforcement agencies, as necessary. Measures in each category were required prior to September 2001. After September 2001, the NRC conducted what the Staff describes as a "comprehensive review" of the NRC's security program. The review considered threats such as a land-based vehicle bomb, ground assault with the use of an insider, and water-borne assaults. Subsequently, security measures at ISFSIs were enhanced in various respects.

The Diablo EA Supplement does not clearly articulate the relationship between defense of the Diablo Canyon ISFSI and defense of other facilities on the site. Elsewhere, the NRC states that its regulations do not require licensees to defend against the DBT that applies at a nuclear power plant, but, in practice, when an ISFSI is located at a reactor site, the ISFSI is typically included within the reactors' security plan. The NRC further states that the Diablo Canyon licensee has amended its reactor security plan to cover the proposed ISFSI.<sup>65</sup> As explained in Section 2.4, above, the DBT at a nuclear power plant is such that the NRC requires only a light defense of the plant.

*Risk-assessment methodology underlying the Diablo EA Supplement*

As explained in Section 3.1, above, the NRC's consideration of design-basis conventional accidents and design-basis threats in a license proceeding is governed by the Atomic Energy Act. By contrast, preparation of an EA or an EIS is governed by NEPA. The NRC has repeatedly accepted that its assessment of conventional accident risks in an EA or an EIS should consider conventional accidents more severe than design-basis conventional accidents. Logic indicates that its assessment of malice-related risks in an EA or an EIS should consider threats more severe than design-basis threats. Preparation of the Diablo EA Supplement has given the NRC Staff an opportunity to apply that logic, and to employ a credible process for assessment of malice-related risks. Section 3, above, has articulated a standard by which to judge the Staff's assessment.

The Diablo EA Supplement does not provide or cite any technical analyses to support its conclusions, nor does it provide an adequate explanation of the assumptions and methodology that underlie those conclusions. The reader is obliged to rely on a brief and incomplete explanation in the Diablo EA Supplement. Apparently, the Staff employed similar assumptions and methodology in preparing the Pa'ina EA Appendix, which provides slightly more information. Neither document provides a clear and complete explanation of the assumptions and methodology used by the Staff to identify and examine attack scenarios and their impacts. From the limited explanations that are provided, it appears that the Staff employed a crude methodology (a "screening and assessment tool") that was originally intended to determine the adequacy of security measures. That issue falls under the Atomic Energy Act, not under NEPA. Also, some of the assumptions employed by the Staff are inappropriate, as discussed below.

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<sup>65</sup> NRC, 2007c, Footnote 10.

The Diablo EA Supplement states (at page 6):

"Following issuance of the 2002 security orders for ISFSIs, NRC used a security assessment framework as a screening and assessment tool, to determine whether additional security measures, beyond those required by regulation and the security orders, were warranted for NRC-regulated facilities, including ISFSIs."

Apparently, that process began by identifying a "spectrum" of threat scenarios. The Diablo EA Supplement does not describe the spectrum. From that spectrum, the Staff identified a set of "plausible" threat scenarios through a screening exercise that is not described in the Supplement. The Pa'ina EA Appendix provides slightly more information about threat screening, stating (at page B-5):

"Remote or speculative scenarios and scenarios with insignificant consequences were screened out based on threat assessments and engineering evaluations".

Threat scenarios deemed to be "plausible" were then examined by the Staff as follows (Diablo EA Supplement, page 6):

"For those scenarios deemed plausible, NRC assessed the attractiveness of the facility to attack by taking into account factors such as iconic value, complexity of planning required, resources needed, execution risk, and public protective measures. In addition, NRC made conservative assessments of consequences, to assess the potential for early fatalities from radiological impacts. NRC then looked at the combined effect of the attractiveness and the consequence analyses, to determine whether additional security measures for ISFSIs were necessary."

These words describe an examination that apparently combined qualitative judgments with quantitative analyses. The Diablo EA Supplement provides no further description of the examination, and does not cite any document that provides such a description. Thus, the completeness and quality of the examination cannot be determined, with one exception. That exception is the use of the "potential for early fatalities" as an indicator of radiological impacts. As explained in Section 4.3, below, the potential for early fatalities is a highly inappropriate indicator of the radiological impacts of accidents or attacks at an ISFSI.

The Diablo EA Supplement describes (at pages 6 and 7) how the Staff used its process to consider threat scenarios and radiological impacts in the context of ISFSIs in general, and in the context of the proposed Diablo ISFSI. That application of the process is discussed in Section 4.2, below.

*The probability of attack*

The Diablo EA Supplement addresses the probability of attack in differing, inconsistent ways. It states (at page 6) that the probability of an attack is "believed to be low", but also that it "cannot be reliably quantified". It also states (at page 6) that enhanced security measures and emergency-planning measures have been implemented at ISFSIs "without regard to the probability of an attack". The Supplement claims (at page 6) that these measures reduce the risk of attack to an "acceptable" level. The Supplement does not explain how acceptability was determined.

The Pa'ina EA Appendix takes a different approach to the probability of attack at commercial nuclear facilities, including irradiators and ISFSIs. It states (at page B-4):

"The NRC staff operates on the premise that a general credible threat exists (i.e., the likelihood of attack has a probability of 1). However, this general credible threat should not be confused with the likelihood of a successful terrorist action (i.e., the probability of a successful attack is <1). Generally in NEPA analysis, the NRC must consider reasonable foreseeable impacts including those from potential accidents. Due to the unique nature of terrorist activities the following discussion focuses on the qualitative probability of a successful attack because at this time it is only possible to assign qualitative probabilities to these events."

The Diablo EA Supplement draws no distinction between the probability of an attack and the conditional probability that the attack will be successful. The Supplement does not indicate whether a "credible" threat or a "plausible" threat is, or is not, equivalent to a "successful attack". From the Pa'ina EA Appendix, one might infer that the "plausible" threats described in the Diablo EA Supplement are thought (by the Staff) to have a comparatively high conditional probability of success. The Supplement provides no clarity on these points.

The Supplement does not provide any framework or terminology for discussing probability in qualitative terms. The Supplement does not discuss the conditional probabilities of radiological impacts and other outcomes of assumed attack scenarios, thereby ignoring an opportunity to partially quantify malice-related risks. Overall, the Supplement provides an inconsistent and incomplete treatment of the probability of attack.

*Role of emergency planning*

The Diablo EA Supplement states (at page 6) that the NRC has "developed emergency planning requirements, which could mitigate potential [radiological] consequences for certain [attack] scenarios [at an ISFSI]". No further explanation is provided, and no document is cited. This statement apparently refers to security-related enhancements that licensees have made in their emergency preparedness (EP) programs, pursuant to

communications from the NRC. These enhancements are not required by current NRC regulations. The NRC Staff has, therefore, sought "Commission approval to begin activities to develop a new voluntary performance-based EP regulatory regimen that could serve as an alternative approach to existing EP regulations and guidance".<sup>66</sup> From that information, one can infer that the Diablo EA Supplement assumes that voluntary EP enhancements would reduce malice-related risks at the Diablo Canyon ISFSI. The Supplement states (at page 7): "In some situations, emergency planning actions could provide an additional measure of protection to help mitigate the consequences, in the unlikely event that an attack were attempted at the Diablo Canyon ISFSI". Apparently, those emergency planning actions would involve voluntary, security-related enhancements.

The NRC Staff's lack of clarity in the Supplement regarding the role of emergency planning illustrates the negative effects of an entrenched culture of secrecy. Effective emergency response requires rapid, coordinated actions by many public and private entities that normally have limited or no engagement with the NRC and the licensee. Secrecy in emergency planning will almost guarantee that confusion and delay would prevail in an actual emergency. Moreover, emergency planning for reactor sites is not currently optimized to address land contamination, which would be the dominant source of radiological impacts following a successful attack on an ISFSI.

#### *Consideration of other nuclear facilities at the Diablo Canyon site*

The Diablo EA Supplement does not discuss risk-related interactions among the proposed ISFSI and other nuclear facilities at the Diablo Canyon site. The Supplement does not mention the cumulative risks arising from operation of all the nuclear facilities at the site. Section 3.2, above, explains the importance of: (i) considering risk-related interactions among nuclear facilities at a site; and (ii) assessing the cumulative risks from operation of those facilities.<sup>67</sup>

#### **4.2 Threat Scenarios and Radiological Impacts Considered by the Staff**

The Diablo EA Supplement provides (at page 6) brief descriptions of: (i) the type of spent-fuel storage module that would be employed at the Diablo Canyon ISFSI; and (ii) the module's purported robustness against attack. The module would function as follows. Spent fuel assemblies would be stored vertically inside a sealed, cylindrical, multi-purpose canister (MPC) made of stainless steel, which would in turn be located inside an overpack. The overpack would consist of two, coaxial, cylindrical, carbon steel shells separated by a layer of concrete, with a fixed baseplate at the bottom and a removable lid at the top. The overpack would be penetrated by cooling vents at its top and bottom, whose purpose would be to allow a flow of ambient air over the outer surface of the MPC, driven by natural convection, to remove radioactive decay heat from the fuel

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<sup>66</sup> Reyes, 2006, page 1.

<sup>67</sup> Related information is provided in: Thompson, 2002.

assemblies. The module would be supplied by Holtec International. This type of module is known as the HI-STORM 100SA System.

To assess the potential for release of radioactive material from a Diablo Canyon module by malicious actions, the NRC Staff relied on generic security assessments for ISFSIs, apparently conducted around 2002. The Diablo EA Supplement states (at page 7): "Plausible threat scenarios considered in the generic security assessments for ISFSIs included a large aircraft impact similar in magnitude to the attacks of September 11, 2001, and ground assaults using expanded adversary characteristics consistent with the design basis threat for radiological sabotage for nuclear power plants." The Supplement later (at page 7) describes these two attack scenarios as "the most severe plausible threat scenarios". Section 4.3, below, addresses the merit of that statement.

The Diablo EA Supplement does not provide any analysis of the radiological impacts of threat scenarios, nor does it cite any document that provides such analysis. The Supplement does not provide any estimate of the radiation dose arising from release of radioactive material, except to say (at page 7) that the dose "would likely be below 5 rem" at the Diablo Canyon site. The Supplement strongly implies that the generic ISFSI assessments yielded the same upper range of dose. That would be consistent with the licensing role of the generic ISFSI assessments, because a dose of 5 rem is the maximum allowable dose for a design-basis accident at an ISFSI.<sup>68</sup>

Obtaining a dose of 5 rem would require only a small release of radioactive material from a storage module. Table 4-1 illustrates this point. It shows, for example, that creation of a hole in an MPC with an equivalent diameter of 2.3 mm would yield a dose of 6.3 rem. Most of that dose would be attributable to release of two-millionths (1.9E-06) of the MPC's inventory of radioisotopes in the "fines" category. That release corresponds to a comparatively small amount of damage to the MPC and the spent fuel within it. Clearly, therefore, the Diablo EA Supplement has not considered a threat scenario that causes substantial damage to an ISFSI module.

#### **4.3 Threat Scenarios and Radiological Impacts that are Relevant to an ISFSI**

The NRC Staff has not provided a credible analysis of threat scenarios and radiological impacts for an ISFSI at Diablo Canyon or elsewhere. Some illustrative analysis is provided here, to show deficiencies in the Diablo EA Supplement. Correcting those deficiencies is a task for the NRC Staff. The illustrative analysis provided here is abbreviated due to the author's concern about dissemination of sensitive information. A

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<sup>68</sup> NRC regulation 10 CFR 72.106(b) limits the radiation dose that any individual located on or beyond the nearest boundary of the controlled area of an ISFSI may receive from any design-basis accident. The dose limit is the more limiting of: (i) a total effective dose equivalent (TEDE) of 5 rem; or (ii) a 50-rem sum of the deep-dose equivalent and the committed dose equivalent to any individual organ. Separate dose limits are also specified for the lens of the eye and for skin or extremities.

much fuller analysis could be provided here, drawing from published literature and general engineering knowledge.<sup>69</sup>

*An ISFSI module's vulnerability to attack*

In some ways, the type of storage module proposed for the Diablo canyon ISFSI (the HI-STORM 100SA System) is a robust structure. The overpack has an outer diameter of 3.7 meters and a height of 5.9 meters. Its outer, carbon steel shell is about 3/4 inch (2 cm) thick, the inner shell is about 1 1/4 inch (3 cm) thick, and the space between these shells is filled by about 27 inches (69 cm) of concrete (details vary by module version).<sup>70</sup> That is a robust structure in terms of its resistance to natural forces (e.g., tornado-driven missiles), but not in terms of its ability to withstand penetration by weapons available to sub-national groups. In any event, the overpack is already penetrated by cooling vents, as described above. The cylindrical wall of the MPC is about 1/2 inch (1.3 cm) thick, and could be readily penetrated by available weapons. The spent fuel assemblies that would be stored inside the MPC are composed of long, narrow tubes made of zirconium alloy, inside which uranium oxide fuel pellets are stacked. The walls of the tubes (the fuel cladding) are about 0.023 inch (0.6 mm) thick and have negligible capacity to withstand penetration by available weapons. Moreover, zirconium is a flammable metal. In finely divided form, it is used in military incendiary devices.

A competent, sub-national group seeking to create offsite radiological impacts by attacking a storage module at the Diablo Canyon ISFSI would probably seek to penetrate the wall of the MPC and ignite the zirconium fuel cladding, with the intent of initiating a fire that would release radioactive material to the atmosphere. A fire could release a substantial fraction of the cesium-137 in affected fuel assemblies, because cesium is a volatile element. The presence of cooling vents at the top and bottom of the module could create a chimney effect that enhances a zirconium fire. For that reason, the attackers could prefer that the module remains upright. The type of module (HI-STORM 100SA System) that the licensee intends to use at the Diablo Canyon ISFSI would remain upright during many attack scenarios, because it is specifically designed to be anchored to its pad. The attackers could seek to exacerbate a fire by enlarging the cooling vents or creating additional holes in the overpack.

*Instruments and modes of attack*

Penetration of the overpack of a storage module (and penetration of the MPC) could be readily accomplished using a shaped charge.<sup>71</sup> These devices have many civilian applications. They are extensively used in the mining and petroleum industries, and for demolition. They have been used in military contexts for decades. Their military applications include, for example, human-carried demolition charges or warheads for anti-tank missiles. Construction and use of shaped charges does not require assistance

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<sup>69</sup> Related information is provided in: Thompson, 2005b; Thompson, 2003.

<sup>70</sup> Holtec FSAR, Chapter 1.

<sup>71</sup> Walters, 2003.

from a government or access to classified information. Many people around the world have experience with these devices in civilian and military contexts.

Table 4-2 provides some information about the shaped charge as a potential instrument of attack. A shaped charge described in that table was designed to penetrate large thicknesses of rock or concrete, as the first stage of a "tandem" warhead (two devices in line, with differing functions). Detailed information about this device has been openly published, but the citation is not provided here. A test proved that the device could create a hole of 25 cm diameter in rock to a depth of almost 6 meters. A device of that size and capability would not be needed to penetrate an ISFSI module. For that application, competent attackers would employ smaller shaped charges, optimized for portability and diameter and depth of hole.

Penetration using a shaped charge would not be the attackers' only option for creating additional holes in the overpack. For example, attackers could use small charges or cutting devices to sever the bolts holding down the lid of the overpack, and then use charges to remove the lid. Boring into or cutting off portions of the overpack could be accomplished using a thermic lance. That device is an iron pipe through which oxygen gas is passed. When the tip is ignited, iron and oxygen react exothermically at a temperature of about 4,000 degrees C. This lance will easily cut through concrete, which melts at 1,800-2,500 degrees C. Steel plates or reinforcing bars will feed the iron-oxygen reaction. This device was developed in France after World War II, to assist the demolition of submarine pens and other large concrete structures that had been built by Nazi Germany. A thermic lance could readily penetrate the MPC in an ISFSI module and ignite the zirconium fuel cladding inside the MPC.

There are various military situations in which attackers seek to penetrate a target (e.g., an armored vehicle, or a concrete bunker) and initiate combustion inside the target. If the attackers achieve direct contact with the target, they might pursue this goal in two, separate steps. First, the target would be penetrated. Second, an incendiary device or material would be inserted through the resulting hole. Often, however, the attack would be made from a distance. For example, an anti-tank missile might be launched from a point tens or hundreds of meters from the target. To accommodate such situations, weapons laboratories and suppliers have developed warheads that combine penetration and incendiary functions. One arrangement is a tandem warhead in which the first stage penetrates the target and the second stage is an incendiary device. A variant of this arrangement employs a "thermobaric" second stage that generates blast and thermal effects.

An attack on the Diablo Canyon ISFSI could be mounted in three different modes, or in combinations of those modes.<sup>72</sup> First, attackers could seek to place themselves in direct contact with ISFSI modules. That mode of attack could involve the use of land vehicles

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<sup>72</sup> Each mode of attack on the ISFSI could be accompanied by diversionary or complementary attacks at other locations.

or airborne vehicles (which could include helicopters or ultralight aircraft) to carry personnel to the ISFSI. Second, attackers could fire guided missiles or other weapons at the ISFSI from ground positions, land vehicles, airborne vehicles, or boats located at distances of hundreds of meters or more from the ISFSI. In illustration of the potential for such an attack, note that the TOW (tube-launched, optically-tracked, wire-guided) missile, which is widely used around the world and which has a proven capability against armored vehicles and bunkers, has a range exceeding 3,000 meters. Third, attackers could use aircraft as improvised cruise missiles, in a kamikaze or remotely-guided configuration.

The Diablo EA Supplement considers the third mode of attack on an ISFSI, but makes the mistaken assumption that a large, fuel-laden commercial aircraft would pose the greatest threat using this attack mode. Large, commercial aircraft caused major damage to the World Trade Center and the Pentagon in September 2001, but they would not be optimal as instruments of attack on an ISFSI. They are comparatively soft objects containing a few hard structures such as turbine shafts. They can be difficult to guide precisely at low speed and altitude. A competent group seeking to attack an ISFSI using an improvised cruise missile would probably prefer to use a smaller, general-aviation aircraft laden with explosive material, perhaps configured as a shaped charge in tandem with incendiary material. In this connection, note that the US General Accounting Office (GAO) expressed concern, in September 2003 testimony to Congress, about the potential for malicious use of general-aviation aircraft. The testimony stated:<sup>73</sup>

"Since September 2001, TSA [the Transportation Security Administration] has taken limited action to improve general aviation security, leaving it far more open and potentially vulnerable than commercial aviation. General aviation is vulnerable because general aviation pilots are not screened before takeoff and the contents of general aviation planes are not screened at any point. General aviation includes more than 200,000 privately owned airplanes, which are located in every state at more than 19,000 airports. Over 550 of these airports also provide commercial service. In the last 5 years, about 70 aircraft have been stolen from general aviation airports, indicating a potential weakness that could be exploited by terrorists."

*Prudent assumptions about attack*

Many people around the world are familiar with the attack principles described in the preceding paragraphs, relevant weapons are available in many countries, and the resources required for an attack are attainable by many sub-national groups. It would, therefore, be prudent to assume that: (i) a sub-national group could mount a credible attack on ISFSI modules at Diablo Canyon; (ii) the group would seek to create a release pathway from the interior of one or more MPCs to the atmosphere; (iii) the group would

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<sup>73</sup> Dillingham, 2003, page 14.

seek to initiate a zirconium fire inside each attacked MPC, to maximize the release of radioactive material to the atmosphere; and (iv) the attack could have a substantial conditional probability of success.

#### *Radiological impacts of attack*

Given the second and third of the assumptions in the preceding paragraph, a successful attack on the Diablo Canyon ISFSI could release to the atmosphere a substantial fraction (tens of percent) of the cesium-137 in each attacked MPC, together with releases of other radioisotopes.<sup>74</sup> Several MPCs could be affected in this manner. Section 2.3, above, discusses a postulated release of 3 million Curies of cesium-137, representing about 50 percent of the cesium-137 in four spent-fuel storage modules. That is a reasonable assumption for the purpose of assessing the radiological impacts of a successful attack.

Land contamination and its sequelae would be the dominant radiological impacts of the release from attacked MPCs. Sequelae would include contamination of food and water, cancers and other adverse health effects that would be manifested years after the release, relocation of populations, abandonment of real estate, and various economic and social impacts. An estimate of economic loss arising from an atmospheric release of 3.5 million Curies of cesium-137, considering five US reactor sites, shows an average loss of \$91 billion.<sup>75</sup> Factors not considered in that estimate could lead to a higher economic loss.

The radiological impacts of potential atmospheric releases from power reactors have been studied for decades. For example, the 1975 *Reactor Safety Study* discussed these impacts in detail.<sup>76</sup> Studies show that a release from a power reactor could lead to early fatalities among downwind populations. The fatalities would be "early" in the sense that they would be manifested within a few weeks or months after the release. Early fatalities would be almost entirely attributable to the release of short-lived radioisotopes, which are present in abundance in the core of an operating reactor. An ISFSI would contain a negligible inventory of short-lived radioisotopes, because it would contain spent fuel that has aged over a period of years. Thus, the potential for early fatalities is a highly inappropriate indicator of the radiological impacts of conventional accidents or attacks at an ISFSI. The NRC Staff's reliance on this indicator in the Diablo EA Supplement provides, by itself, sufficient grounds to reject the conclusions of the Supplement.

#### **4.4 Options for Reducing the Risks of Malicious Actions**

The Diablo EA Supplement provides (at page 3) a limited discussion of alternatives to the proposed ISFSI. These alternatives fall into three categories: (i) shipment of spent fuel offsite; (ii) other methods of storing spent fuel onsite; and (iii) no action, leading to shutdown of the Diablo Canyon reactors. In discussing other methods of storing spent

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<sup>74</sup> The fractional release of each radioisotope would be determined by the isotope's physical and chemical properties as an element.

<sup>75</sup> Beyea et al, 2004.

<sup>76</sup> NRC, 1975, Appendix VI.

fuel onsite, the Supplement considers an increase in the capacity of the existing spent-fuel pools at the site, or construction of a new pool, and rejects both options. The Supplement does not discuss the option of constructing the ISFSI using a design that is more robust against attack than the design proposed by the licensee.

The Supplement does not mention the *National Infrastructure Protection Plan*. It does not discuss homeland-security strategy, the principles of protective deterrence, or the opportunities that the NIPP has identified for incorporating protective features into the design of infrastructure elements.

*Increasing the ISFSI's robustness against attack*

Options for designing a Diablo Canyon ISFSI to be more robust against attack have been identified by this author, as follows:<sup>77</sup> "re-design of the ISFSI to use thick-walled metal casks, dispersal of the casks, and protection of the casks by berms or bunkers in a configuration such that pooling of aircraft fuel would not occur in the event of an aircraft impact". Elsewhere, the author has provided a more detailed discussion about designing an ISFSI to be more robust against attack.<sup>78</sup> A factor addressed in that discussion is the possibility that society will extend the life of ISFSIs until they become, by default, repositories for spent fuel. Consideration of that possibility could favor an above-ground ISFSI whose robustness would be enhanced through a combination of the design options described above.

Holtec International has developed a design for a new ISFSI storage module that is said to be more robust against attack than present modules. The new module is the HI-STORM 100U module, which would employ the same MPC as is proposed for the Diablo Canyon ISFSI. For most of its height, the 100U module would be underground. Holtec has described the robustness of the 100U module as follows:<sup>79</sup>

"Release of radioactivity from the HI-STORM 100U by any mechanical means (crashing aircraft, missile, etc.) is virtually impossible. The only access path into the cavity for a missile is vertically downward, which is guarded by an arched, concrete-fortified steel lid weighing in excess of 10 tons. The lid design, at present configured to easily thwart a crashing aircraft, can be further buttressed to withstand more severe battlefield weapons, if required in the future for homeland security considerations. The lid is engineered to be conveniently replaceable by a later model, if the potency of threat is deemed to escalate to levels that are considered non-credible today."

The design of the Holtec 100U module has been under review by the NRC Staff. The Staff has expressed concern about seismic-related structural analyses performed for this design, and in late 2006 Holtec withdrew its application for a Certificate of Compliance

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<sup>77</sup> Thompson, 2002, paragraph XI-5.

<sup>78</sup> Thompson, 2003.

<sup>79</sup> Holtec, 2007.

for the 100U module. Further discussions were held between Holtec and the Staff on 27 March 2007, described by the Staff as follows:<sup>80</sup>

"At the meeting, Holtec presented new and revised structural analyses in response to the staff's concerns. The staff responded positively to the material presented by Holtec and indicated that it appeared the staff's concerns had been addressed. A new application is scheduled to be submitted by the end of April 2007."

It appears that the Holtec 100U module may soon receive a Certificate of Compliance from the NRC. At that point, the 100U module would be available for use in the Diablo Canyon ISFSI.

#### *Enhancing active defense of the ISFSI*

As currently proposed, the Diablo Canyon ISFSI would receive an active defense involving the deployment of armed guards and related security measures. That form of defense contrasts with the passive defense provided by a facility's inherent robustness against attack.

Active defense of the ISFSI could be enhanced by employing additional security measures, such as anti-aircraft guns or missiles. The Diablo EA Supplement does not discuss that option. A thorough assessment of malice-related risks at the Diablo Canyon ISFSI should consider the merits of enhancing active defense as a risk-reducing option. In considering that option, the assessment should recognize that active defense has substantial costs, both monetary and societal, that could be avoided by enhancing the ISFSI's inherent robustness.<sup>81</sup>

#### *Enhancing capabilities for damage control*

As discussed in Section 4.3, above, it would be prudent to assume that a group attacking the Diablo Canyon ISFSI would seek to create a release pathway from the interior of one or more MPCs to the atmosphere, and to initiate a zirconium fire inside each attacked MPC in order to maximize the release of radioactive material to the atmosphere. To counter those ambitions, the licensee could improve its capabilities for damage control, seeking to minimize the radioactive release in the event of an attack. Relevant capabilities would include: (i) availability of personnel trained and equipped to work in a high-radiation environment; and (ii) deployment of devices and materials to suppress fires and limit releases of radioactive material. A thorough assessment of malice-related

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<sup>80</sup> Johnson, 2007, Enclosure C.

<sup>81</sup> In October 2001 the French government deployed anti-aircraft missiles at the La Hague nuclear site. Deployment of anti-aircraft guns or missiles to defend the Diablo Canyon ISFSI would require the ongoing presence of US military personnel, to maintain and operate these weapons. Complex questions of command authority for firing of the weapons would need to be addressed. These factors would generate substantial monetary and societal costs.

risks at the Diablo Canyon ISFSI should consider the merits of enhancing capabilities for damage control as a risk-reducing option.

#### **4.5 An Overall Evaluation of the Staff's Supplement**

Section 2 of this report provides a broad perspective on potential malicious actions at nuclear facilities. That perspective shows the importance of conducting thorough assessments of malice-related risks and options for reducing those risks. Section 3 sets forth an appropriate framework for assessing malice-related risks, thereby providing a standard for evaluating the Diablo EA Supplement. Sections 4.1 through 4.4 review various aspects of the Supplement. Major findings of the review include:

- (i) the Supplement neither provides technical analysis nor cites any document that provides such analysis;
- (ii) in preparing the Supplement, the NRC Staff relied on an unexplained process to identify plausible threat scenarios;
- (iii) the Staff failed to consider threat scenarios that are more severe and at least as plausible as the threat scenarios that it did consider;
- (iv) the Staff relied on a crude, partially explained methodology to assess malice-related risks;
- (v) the Staff employed a highly inappropriate indicator of the radiological impacts of attacks, namely the potential for early fatalities;
- (vi) the Supplement greatly under-estimates the scale of radiological impacts of attacks and ignores the dominant impacts, which would arise from land contamination;
- (vii) the Supplement ignores the NIPP and the potential that it articulates for increasing the inherent robustness of infrastructure facilities against attack;
- (viii) the Supplement fails to consider options for reducing malice-related risks at the proposed Diablo Canyon ISFSI through measures including the use of more robust fuel storage modules; and
- (ix) the Supplement fails to consider ISFSI-related risks in the context of risks associated with other nuclear facilities on the Diablo Canyon site.

These are grave deficiencies. The Diablo EA Supplement is not credible.

## **5. Conclusions**

Major conclusions of this report are as follows:

C1. It would be prudent to assume that power reactors, spent-fuel pools and ISFSIs in the US will be attacked by capable sub-national groups during the coming decades.

C2. Given present designs and defenses of these facilities, there is a substantial probability that an attack by a capable sub-national group would cause a release to the environment of a large amount of radioactive material, yielding severe radiological consequences.

C3. Design options are available that could increase the inherent robustness of commercial nuclear facilities against attack, especially in the case of new facilities such as the proposed Diablo Canyon ISFSI.

C4. Increasing the inherent robustness of infrastructure facilities against attack is envisioned in the *National Infrastructure Protection Plan*, and would support a national strategy of protective deterrence.

C5. Present methodologies for risk assessment could be adapted to provide operationally-useful assessments of: (i) the risks of malicious actions at commercial nuclear facilities; and (ii) the potential for reducing those risks through alternative options.

C6. The Diablo EA Supplement has grave deficiencies as summarized in Section 4.5, above, and is not credible.

C7. A credible assessment of malice-related risks at the proposed Diablo Canyon ISFSI would correct the deficiencies in the Diablo EA Supplement and would consider a range of risk-reducing options, including design options that enhance robustness of the ISFSI and limits on future production of spent fuel.

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**Table 2-1  
Public Opinion in Four Muslim Countries Regarding the US "War on Terrorism"**

Country	Percentage of Respondents Who Think that the Primary Goal of What the US Calls "the War on Terrorism" is to:		
	Weaken and Divide the Islamic Religion and its People	Achieve Political and Military Domination to Control Middle East Resources	Protect Itself from Terrorist Attacks
Morocco	33	39	19
Egypt	31	55	9
Pakistan	42	26	12
Indonesia	29	24	23

**Notes:**

(a) Data are from: Steven Kull et al, *Muslim Public Opinion on US Policy, Attacks on Civilians and al Qaeda*, Program on International Policy Attitudes, University of Maryland, 24 April 2007.

(b) Percentages not shown in each row are "do not know" or "no response".

**Table 2-2  
Future World Scenarios Identified by the Stockholm Environment Institute**

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

**Source:**  
Paul Raskin et al, *Great Transition: The Promise and Lure of the Times Ahead*, Stockholm Environment Institute, 2002.

**Table 2-3  
Selected Approaches to Protecting US Critical Infrastructure From Attack by Sub-National Groups, and Some of the Strengths and Weaknesses of these Approaches**

<b>Approach</b>	<b>Strengths</b>	<b>Weaknesses</b>
Offensive military operations internationally	<ul style="list-style-type: none"> <li>• Can deter or prevent governments from supporting sub-national groups hostile to the US</li> </ul>	<ul style="list-style-type: none"> <li>• Can promote growth of sub-national groups hostile to the US, and build sympathy for these groups in foreign populations</li> <li>• Can be costly in terms of lives, money and national reputation</li> </ul>
International police cooperation within a legal framework	<ul style="list-style-type: none"> <li>• Can identify and intercept potential attackers</li> </ul>	<ul style="list-style-type: none"> <li>• Implementation can be slow and/or incomplete</li> <li>• Requires ongoing international cooperation</li> </ul>
Surveillance and control of the domestic population	<ul style="list-style-type: none"> <li>• Can identify and intercept potential attackers</li> </ul>	<ul style="list-style-type: none"> <li>• Can destroy civil liberties, leading to political, social and economic decline of the nation</li> </ul>
Active defense of infrastructure facilities (by use of guards, guns, gates, etc.)	<ul style="list-style-type: none"> <li>• Can stop attackers before they reach the target</li> </ul>	<ul style="list-style-type: none"> <li>• Can involve higher operating costs</li> <li>• Requires ongoing vigilance</li> <li>• May require military involvement</li> </ul>
Resilient design, passive defense, and related protective measures for infrastructure facilities (as envisioned in the NIPP)	<ul style="list-style-type: none"> <li>• Can allow target to survive attack without damage, thereby enhancing protective deterrence</li> <li>• Can substitute for other protective approaches, avoiding their costs and adverse impacts</li> <li>• Can reduce risks from accidents, natural hazards, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Can involve higher capital costs</li> </ul>

**Table 2-4**  
**Estimated Amounts of Cesium-137 in Nuclear Fuel Associated With Diablo Canyon Unit 1 or Unit 2**

Category of Nuclear Fuel	Amount of Cesium-137 (million Curies)
One spent fuel assembly at discharge from reactor (17.5 MWt per assembly, 90% capacity factor, discharge after 44 months, 520 kgU/assembly)	0.064
One reactor core at operating equilibrium (193 assemblies, av. burnup = 50% of discharge burnup)	6.2
One spent-fuel pool at full loading, allowing space for full-core discharge (1,131 assemblies, av. age after discharge = 10 yr)	57
One ISFSI module at full capacity (32 assemblies, av. age after discharge = 20 yr)	1.3

**Notes:**

- (a) The radionuclide inventory of Ginna spent fuel batch 16 is estimated in: V.L. Sailor et al, *Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82*, NUREG/CR-4982, July 1987. From Tables A.11 and A.13 of that document, one finds that the inventory of Cs-137 in newly-discharged spent fuel is 3.05 kCi per GWt-day of fission energy yield. For the assumed conditions of a Diablo Canyon fuel assembly at discharge, this inventory is 0.064 MCi. Almost the same result (0.065 MCi) can be obtained by direct calculation, assuming an energy yield of 200 MeV per fission and a Cs-137 fission fraction of 6.0 percent.
- (b) The assumed conditions of a Diablo Canyon fuel assembly at discharge are equivalent to a burnup of 41 MWt-days per kgU.
- (c) The mass of 1 MCi of Cs-137 is 11 kg.

**Table 2-5  
Illustrative Inventories of Cesium-137**

Case	Inventory of Cesium-137 (Curies)
Produced during detonation of a 10-kilotonne fission weapon	1,800
Released to atmosphere during the Chernobyl reactor accident of 1986	2.4 million
Released to atmosphere during nuclear-weapon tests, primarily in the 1950s and 1960s (Fallout was non-uniformly distributed across the planet, mostly in the Northern hemisphere.)	20 million
Currently in reactor core of Diablo Canyon Unit 1 or Unit 2	6.2 million
Currently in spent-fuel pool of Diablo Canyon Unit 1 or Unit 2	57 million
In a typical module of a Diablo Canyon ISFSI	1.3 million

**Notes:**

(a) Inventories in the first three rows are from Table 3-2 of: Gordon Thompson, *Reasonably Foreseeable Security Events: Potential threats to options for long-term management of UK radioactive waste*, A report for the UK government's Committee on Radioactive Waste Management, IRSS, 2 November 2005.

(b) Inventories in rows four through six are author's estimates set forth in Table 2-3 of this report.

**Table 2-6  
Some Potential Modes and Instruments of Attack on a Nuclear Power Plant**

<b>Attack Mode/Instrument</b>	<b>Characteristics</b>	<b>Present Defense</b>
Commando-style attack	<ul style="list-style-type: none"> <li>• Could involve heavy weapons and sophisticated tactics</li> <li>• Successful attack would require substantial planning and resources</li> </ul>	Alarms, fences and lightly-armed guards, with offsite backup
Land-vehicle bomb	<ul style="list-style-type: none"> <li>• Readily obtainable</li> <li>• Highly destructive if detonated at target</li> </ul>	Vehicle barriers at entry points to Protected Area
Anti-tank missile	<ul style="list-style-type: none"> <li>• Readily obtainable</li> <li>• Highly destructive at point of impact</li> </ul>	None if missile launched from offsite
Commercial aircraft	<ul style="list-style-type: none"> <li>• More difficult to obtain than pre-9/11</li> <li>• Can destroy larger, softer targets</li> </ul>	None
Explosive-laden smaller aircraft	<ul style="list-style-type: none"> <li>• Readily obtainable</li> <li>• Can destroy smaller, harder targets</li> </ul>	None
10-kilotonne nuclear weapon	<ul style="list-style-type: none"> <li>• Difficult to obtain</li> <li>• Assured destruction if detonated at target</li> </ul>	None

**Notes:**

- This table is adapted from a table, supported by analysis and citations, in: Gordon Thompson, *Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security*, IRSS, January 2003. Later sources confirming this table include:
- (a) Gordon Thompson, testimony before the California Public Utilities Commission regarding Application No. 04-02-026, 13 December 2004.
  - (b) Jim Wells, US Government Accountability Office, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
  - (c) Marvin Fertel, Nuclear Energy Institute, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
  - (d) Danielle Brian, Project on Government Oversight, letter to NRC chair Nils J. Diaz, 22 February 2006.
  - (e) National Research Council, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, National Academies Press, 2006.

**Table 2-7  
Potential Sabotage Events at a Spent-Fuel-Storage Pool, as Postulated in the NRC's  
August 1979 GEIS on Handling and Storage of Spent LWR Fuel**

<b>Event Designator</b>	<b>General Description of Event</b>	<b>Additional Details</b>
Mode 1	<ul style="list-style-type: none"> <li>• Between 1 and 1,000 fuel assemblies undergo extensive damage by high-explosive charges detonated under water</li> <li>• Adversaries commandeer the central control room and hold it for approx. 0.5 hr to prevent the ventilation fans from being turned off</li> </ul>	<ul style="list-style-type: none"> <li>• One adversary can carry 3 charges, each of which can damage 4 fuel assemblies</li> <li>• Damage to 1,000 assemblies (i.e., by 83 adversaries) is a "worst-case bounding estimate"</li> </ul>
Mode 2	<ul style="list-style-type: none"> <li>• Identical to Mode 1 except that, in addition, an adversary enters the ventilation building and removes or ruptures the HEPA filters</li> </ul>	
Mode 3	<ul style="list-style-type: none"> <li>• Identical to Mode 1 within the pool building except that, in addition, adversaries breach two opposite walls of the building by explosives or other means</li> </ul>	<ul style="list-style-type: none"> <li>• Adversaries enter the central control room or ventilation building and turn off or disable the ventilation fans</li> </ul>
Mode 4	<ul style="list-style-type: none"> <li>• Identical to Mode 1 except that, in addition, adversaries use an additional explosive charge or other means to breach the pool liner and 5-ft-thick concrete floor of the pool</li> </ul>	

**Notes:**

(a) Information in this table is from Appendix J of: USNRC, *Generic EIS on Handling and Storage of Spent Light Water Power Reactor Fuel*, NUREG-0575, August 1979.

(b) The postulated fuel damage ruptures the cladding of each rod in an affected fuel assembly, releasing "contained gases" (gas activity) to the pool water, whereupon the released gases bubble to the water surface and enter the air volume above that surface.

**Table 4-1  
Estimated Release of Radioactive Material and Downwind Inhalation Dose for  
Blowdown of the MPC in a Spent Fuel Storage Module**

Indicator		MPC Leakage Area		
		4 sq. mm (equiv. dia. = 2.3 mm)	100 sq. mm (equiv. dia. = 11 mm)	1,000 sq. mm (equiv. dia. = 36 mm)
<b>Fuel Release Fraction</b>	<b>Gases</b>	3.0E-01	3.0E-01	3.0E-01
	<b>Crud</b>	1.0E+00	1.0E+00	1.0E+00
	<b>Volatiles</b>	2.0E-04	2.0E-04	2.0E-04
	<b>Fines</b>	3.0E-05	3.0E-05	3.0E-05
<b>MPC Blowdown Fraction</b>		9.0E-01	9.0E-01	9.0E-01
<b>MPC Escape Fraction</b>	<b>Gases</b>	1.0E+00	1.0E+00	1.0E+00
	<b>Crud</b>	7.0E-02	5.0E-01	8.0E-01
	<b>Volatiles</b>	4.0E-03	3.0E-01	6.0E-01
	<b>Fines</b>	7.0E-02	5.0E-01	8.0E-01
<b>Inhalation Dose (CEDE) to a Person at a Distance of 900 m</b>		6.3 rem	48 rem	79 rem

**Notes:**

- (a) Estimates are from: Gordon Thompson, *Estimated Downwind Inhalation Dose for Blowdown of the MPC in a Spent Fuel Storage Module*, IRSS, June 2007.
- (b) The assumed multi-purpose canister (MPC) contains 24 PWR spent fuel assemblies with a burnup of 40 MWt-days per kgU, aged 10 years after discharge.
- (c) The following radioisotopes were considered: Gases (H-3, I-129, Kr-85); Crud (Co-60); Volatiles (Sr-90, Ru-106, Cs-134, Cs-137); Fines (Y-90 and 22 other isotopes).
- (d) The calculation followed NRC guidance for calculating radiation dose from a design-basis accident, except that the MPC Escape Fraction was drawn from a study by Sandia National Laboratories that used the MELCOR code package.
- (e) CEDE = committed effective dose equivalent. In this scenario, CEDE makes up most of the total dose (TEDE) and is a sufficient approximation to it.
- (f) The overall fractional release of a radioisotope from fuel to atmosphere is the product of Fuel Release Fraction, MPC Blowdown Fraction, and MPC Escape Fraction.
- (g) For a leakage area of 4 square mm, the overall fractional release is: Gases (0.27); Crud (0.063); Volatiles (7.2E-07); Fines (1.9E-06). Fines account for 95 percent of CEDE, and Crud accounts for 4 percent.

**Table 4-2  
The Shaped Charge as a Potential Instrument of Attack**

<b>Category of Information</b>	<b>Selected Information in Category</b>
General information	<ul style="list-style-type: none"> <li>• Shaped charges have many civilian and military applications, and have been used for decades</li> <li>• Applications include human-carried demolition charges or warheads for anti-tank missiles</li> <li>• Construction and use does not require assistance from a government or access to classified information</li> </ul>
Use in World War II	<ul style="list-style-type: none"> <li>• The German MISTEL, designed to be carried in the nose of an un-manned bomber aircraft, is the largest known shaped charge</li> <li>• Japan used a smaller version of this device, the SAKURA bomb, for kamikaze attacks against US warships</li> </ul>
A large, contemporary device	<ul style="list-style-type: none"> <li>• Developed by a US government laboratory for mounting in the nose of a cruise missile</li> <li>• Described in an unclassified, published report (citation is voluntarily withheld here)</li> <li>• Purpose is to penetrate large thicknesses of rock or concrete as the first stage of a "tandem" warhead</li> <li>• Configuration is a cylinder with a diameter of 71 cm and a length of 72 cm</li> <li>• When tested in November 2002, created a hole of 25 cm diameter in tuff rock to a depth of 5.9 m</li> <li>• Device has a mass of 410 kg; would be within the payload capacity of many general-aviation aircraft</li> </ul>
A potential delivery vehicle	<ul style="list-style-type: none"> <li>• A Beechcraft King Air 90 general-aviation aircraft will carry a payload of up to 990 kg at a speed of up to 460 km/hr</li> <li>• A used King Air 90 can be purchased in the US for \$0.4-1.0 million</li> </ul>

**Source:**

Gordon Thompson, Institute for Resource and Security Studies, testimony before the Public Utilities Commission of the State of California regarding Application No. 04-02-026, 13 December 2004.

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of: :  
: :  
PACIFIC GAS & ELECTRIC CO. : Docket No. 72-26 - ISFSI  
(Diablo Canyon Nuclear Power Plant :  
Unit Nos. 1 and 2) :

SECOND DECLARATION OF DR. GORDON R. THOMPSON  
ON BEHALF OF SAN LUIS OBISPO MOTHERS FOR PEACE  
IN SUPPORT OF CONTENTION 2 REGARDING THE CONSTRUCTION AND  
OPERATION OF THE DIABLO CANYON INDEPENDENT SPENT  
FUEL STORAGE INSTALLATION

I, Gordon R. Thompson, state the following:

**I. Introduction**

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

I-2. I am an expert in the technical analysis of safety, security and environmental issues related to nuclear facilities. Information about my relevant experience and expertise, together with an attached copy of my curriculum vitae, are provided in my declaration of 27 June 2007 in this matter.<sup>1</sup> That declaration accompanied a report that I prepared for San Luis Obispo Mothers for Peace (SLOMFP).<sup>2</sup> My declaration and report supported contentions submitted by SLOMFP in this matter.<sup>3</sup>

I-3. Here, I set forth facts, data and arguments to support SLOMFP Contention 2.

I-4. SLOMFP's contentions responded to the publication by the Staff of the US Nuclear Regulatory Commission (NRC) of a Supplement to the Environmental Assessment (EA) for a proposed Independent Spent Fuel Storage Installation (ISFSI) at the Diablo Canyon

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<sup>1</sup> Thompson, 2007d.

<sup>2</sup> Thompson, 2007b.

<sup>3</sup> SLOMFP, 2007.

site. The EA Supplement was published in draft and final versions, in May 2007 and August 2007, respectively.<sup>4</sup>

I-5. The remainder of this declaration consists of narrative discussion set forth in Sections II through VII, together with a bibliography and three tables. All citations in the footnotes and the tables are to documents listed in the bibliography. Some additional, relevant documents also appear in the bibliography.

## **II. SLOMFP Contention 2 and Its Context**

II-1. SLOMFP Contention 2 states as follows:<sup>5</sup>

"The EA Supplement fails to satisfy NEPA because the NRC's decision not to prepare an EIS is based on hidden and unjustified assumptions."

II-2. In setting forth the basis for Contention 2, SLOMFP provided examples of the EA Supplement's reliance on hidden and unjustified assumptions. A notable example was the EA Supplement's apparent assumption that the environmental impacts of an attack on a spent-fuel-storage module would be insignificant if the attack does not result in early fatalities. That assumption can be inferred because the EA Supplement, in discussing the consequences of a release of radioactive material arising from an attack on an ISFSI, provided only one direct indicator of an adverse outcome, namely "the potential for early fatalities".<sup>6</sup> It should be noted that the NRC uses the terms "early fatalities" and "prompt fatalities" interchangeably.

II-3. My report in support of SLOMFP's contentions shows that the potential for early fatalities is an inappropriate indicator of the environmental impacts of an attack. Other consequences of an attack, especially land contamination and its sequelae, would have considerably greater significance. A credible attack on the Diablo Canyon ISFSI could release to the atmosphere tens of percent of the inventory of cesium-137 in affected spent-fuel-storage modules. Deposition of cesium-137 from that release could render thousands of square kilometers of land uninhabitable. Sequelae would include contamination of food and water, cancers and other adverse health effects that would be manifested years after the release, relocation of populations, abandonment of real estate, and various economic and social impacts. Economic losses could amount to tens of billions of dollars.<sup>7</sup>

II-4. The NRC Commissioners have admitted Contention 2 into this proceeding, in regard to the scope of the consequences considered in the EA Supplement.<sup>8</sup> I address that issue here, in its appropriate context. The scope of the consequences of a potential attack on the Diablo Canyon ISFSI could only be properly understood as part of a

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<sup>4</sup> NRC, 2007b; NRC, 2007a.

<sup>5</sup> SLOMFP, 2007, page 10.

<sup>6</sup> NRC, 2007b, page 6. An equivalent statement appears at: NRC, 2007a, page 7.

<sup>7</sup> Thompson, 2007b, pages 17 and 37.

<sup>8</sup> NRC, 2008a, pp 20-21.

comprehensive assessment of the environmental impacts of such an attack. SLOMFP does not have the funds needed to conduct such an assessment, nor does SLOMFP have the duty to do so. Nevertheless, SLOMFP fully understands the steps needed to conduct such an assessment, and has constructed its contentions accordingly. My report in support of SLOMFP's contentions, and this testimony, reflect that understanding. Both documents provide illustrative analyses to support their arguments. Neither document purports to provide a comprehensive assessment of environmental impacts.

II-5. A comprehensive assessment of environmental impacts, as discussed in the preceding paragraph, would begin by identifying and characterizing a range of credible attacks. Then, for each type of attack, the assessment would estimate the release of radioactive material to the environment. In the case of an attack on an ISFSI, the most significant mode of release would be to the atmosphere. Next, the assessment would model the dispersal of radioactive material in the environment. That step would include site-specific factors that significantly affect the behavior of atmospheric plumes. Then, the assessment would estimate human exposure to the released radioactive material by all significant pathways. Finally, the assessment would estimate the health, environmental, social and economic impacts, both direct and indirect, that arise from the potential for attack-induced release of radioactive material.

II-6. The NRC Staff has not conducted a comprehensive assessment, as specified in the preceding paragraph, for the Diablo Canyon ISFSI. Analysis that the Staff has conducted is reviewed in subsequent sections of this testimony. The requirements of a comprehensive assessment provide a framework for that review.

### **III. NRC Staff Position Regarding the Potential for Early Fatalities**

III-1. As stated in paragraph II-2, above, the EA Supplement provided only one direct indicator of an adverse outcome of an attack on an ISFSI, namely the potential for early fatalities.<sup>9</sup> Thus, SLOMFP has inferred that the NRC Staff, in preparing the EA Supplement, assumed that the environmental impacts of an attack on an ISFSI would be insignificant if the attack does not result in early fatalities. Information subsequently provided by the NRC Staff in this proceeding has confirmed SLOMFP's inference. That information relates to research reactors and related facilities, and to ISFSIs, as described in the following paragraphs.

III-2. In the document, SECY-04-0222, dated 24 November 2004, the NRC Staff submitted to the NRC Commissioners a proposed decision-making framework for vulnerability assessments for materials and research and test reactors.<sup>10</sup> SECY-04-0222 stated, at page 3:

"Several methodologies for conducting and evaluating comprehensive VAs [vulnerability assessments] for different types of assets are currently under

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<sup>9</sup> The EA Supplement also discussed the estimated radiation dose to an individual, which is an indirect indicator of an adverse outcome. That issue is discussed here in Section IV.

<sup>10</sup> Reyes, 2004.

development. In particular, the ASME, in cooperation with numerous stakeholders, is funded by DHS to develop the RAMCAP methodology. This methodology is designed to inform the allocation of resources to protect infrastructure components."

SECY-04-0222 went on to state, at page 4:

"As discussed in this paper, the consequences considered are prompt fatalities from radiation exposure and those chemical effects associated with radioactive material processes (i.e., UF<sub>6</sub>). Past Commission policy and practice has varied with respect to consideration of consequence criteria. The proposed VA decision-making framework uses only prompt fatalities as a consequence criterion.

It is also recognized that other guidance, such as the draft RAMCAP methodology, uses other consequence criteria. For example, RAMCAP uses criteria such as economic, environmental, national security, symbolic and sociopolitical impacts, and loss of output or production capability as metrics for national level screening.

Other related radiological consequence criteria that could be incorporated in the framework include latent fatalities, land contamination, and chemical risks due to plant conditions which affect the safety of radioactive materials [words redacted]. Including some of these consequence criteria may also be consistent with the goal, in the NRC's Strategic Plan, to ensure protection of public health and safety and the environment, and also with the section on commercial nuclear reactors in the National Infrastructure Protection Plan. There are various points of view within the staff on the need for additional criteria, e.g., land contamination.

The staff also recognizes that exposure to certain radioactive materials [words redacted] would not result in a prompt fatality or the need for additional measures. However, using other consequence criteria (e.g., land contamination) may require additional security measures."

III-3. The NRC Commissioners subsequently provided a written response, dated 19 January 2005, to the recommendations proffered by the Staff in SECY-04-0222.<sup>11</sup> The Commissioners stated, at page 1:

"The Commission specifically approves, as recommended by the staff, the use of prompt fatalities as the consequence analysis in the decision-making framework for this activity."

The Commissioners went on to state, at page 3:

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<sup>11</sup> Vietti-Cook, 2005.

"As a separate issue from the vulnerability assessments conducted under the decision making framework, the staff should not be independently developing criteria and standards for other consequences (such as land contamination and economic impacts) at this time. Rather, consistent with the US government programs for homeland protection and security, the staff should continue to support the separate vulnerability assessment reviews being conducted under the leadership of the Department of Homeland Security (DHS). These activities include the consideration of consequences other than prompt fatalities."

III-4. The Staff's recommendations in SECY-04-0222, and the Commissioner's written response to those recommendations, did not explicitly cover ISFSIs. However, a subsequent Memo sent from one Staff office to another did explicitly link SECY-04-0222 with ISFSIs.<sup>12</sup> The Memo, dated 9 December 2005, stated at page 1:

"In response to Chairman Meserve's memorandum, "Response to Terrorist Acts", dated September 28, 2001, and in accordance with SRM-SECY-04-0222, "Decision-Making Framework for Materials and Research and Test Reactor Vulnerability Assessments", the Spent Fuel Project Office (SFPO) staff performed framework assessments for spent fuel storage casks and transportation packages and radioactive material transportation packages for various potential terrorist threats."

III-5. From that statement, it is evident that the NRC Staff, in performing framework assessments of the vulnerability of ISFSIs to attack, acted "in accordance with" the approach set forth in SECY-04-0222. It follows that the Staff, in considering the consequences of an attack on an ISFSI, limited its consideration to the potential for early fatalities.

III-6. The Government Accountability Office (GAO) reviewed, in a January 2008 report, NRC's assessment of the vulnerability of research reactors to attack.<sup>13</sup> GAO's general conclusion is evident in the report's title, *Nuclear Security: Action May be Needed to Reassess the Security of NRC-Licensed Research Reactors*. GAO noted NRC's reliance on the potential for early fatalities as the sole indicator of the consequences of attack. GAO used the term "immediate fatalities", which is equivalent to "early fatalities". The GAO report stated, at page 8:

"NRC used the number of immediate fatalities caused by radiological release resulting from an attack at a research reactor as its criterion to measure consequences and assessed [assess] the adequacy of the security at NRC-licensed reactors."

III-7. In preparing the above-mentioned report, GAO obtained independent advice on the vulnerability of research reactors to attack, and on the consequences of such an attack,

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<sup>12</sup> Strosnider, 2005.

<sup>13</sup> GAO, 2008.

and reviewed the findings of the US Department of Energy (DOE) and Sandia National Laboratories (SNL) on these matters.<sup>14</sup> Analysts at Idaho National Laboratory (INL) and the Department of Homeland Security (DHS) advised GAO that a credible attack on a research reactor could cause a release of radioactive material substantially larger than NRC assumes. An INL analyst advised GAO that the consequences of an attack could include significant land contamination. GAO noted that DOE has determined that the consequences of an attack at some of its research reactors could be severe, potentially involving the dispersion of radioactive material over many square miles. GAO also noted that SNL had, under contract to NRC, assessed the vulnerability of research reactors. SNL concluded that some credible attacks could be successful. NRC disagreed, and concluded that radiological consequences of credible attacks would be minimal.

III-8. The NRC Commissioners' response of 19 January 2005 to SECY-04-0222 stated, at page 1:<sup>15</sup>

"The Commission continues to support its earlier direction that Sandia National Laboratories' draft vulnerability assessments not be shared with industry and should not be released to anyone outside the agency."

III-9. From that statement, it appears that the Commissioners sought to suppress a differing professional opinion that was developed by SNL while working under contract to NRC. The existence of that differing opinion was not publicly known until the publication of GAO's report in January 2008. Moreover, as shown in paragraph III-3, above, the Commissioners ordered the Staff to refrain from independently developing criteria and standards for attack consequences other than early fatalities. These actions by the Commissioners were taken with direct application to research reactors and related facilities. As shown by paragraphs III-4 and III-5, above, it appears that these actions also apply to ISFSIs.

III-10. From the preceding paragraphs, it can reasonably be concluded that NRC has made a policy choice to consider only one category of environmental impacts of an attack on an ISFSI, namely the potential for early fatalities. Also, in the context of research reactors and related facilities, NRC has made policy choices to not consider attack scenarios that SNL and other authorities have determined to be credible, and to not consider environmental impacts other than the potential for early fatalities. A motive for the latter choice can be inferred from an NRC Staff statement quoted in paragraph III-2, above, that "using other consequence criteria (e.g., land contamination) may require additional security measures". Additional security measures would involve additional costs. Thus, by not considering environmental impacts such as land contamination, NRC may have allowed licensees to avoid additional costs. It can reasonably be inferred that NRC has taken essentially the same approach in the context of ISFSIs.

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<sup>14</sup> GAO, 2008, pp 14-18.

<sup>15</sup> Vietti-Cook, 2005.

#### **IV. NRC Staff Estimation of Radiation Dose to an Individual**

IV-1. As noted in subsequent paragraphs, the NRC Staff has released a succession of documents that discuss its estimation of the radiation dose to an individual following an attack on the Diablo Canyon ISFSI. Each successive document contains additional information, but the publicly available description of the Staff's assumptions and analyses remains incomplete. For example, the Staff has not disclosed the composition of the atmospheric release for which it estimates a radiation dose.

IV-2. As explained in Section VI, below, it appears that the Staff's process of estimating the radiation dose to an individual has been fundamentally shaped by NRC's policy choice to consider only one category of environmental impacts of an attack on an ISFSI, namely the potential for early fatalities. That policy choice has led the Staff to confine its analysis of radiological consequences to a particular category of radiation exposure, and to refrain from considering potential releases of radioactive material that are significant in regard to other categories of radiation exposure. In other words, NRC's policy choice has precluded a thorough, science-based assessment of the environmental impacts of a credible attack on the Diablo Canyon ISFSI.

IV-3. The NRC Staff's May 2007 EA Supplement for the Diablo Canyon ISFSI discussed, at page 7, the factors relevant to radiation dose arising from an attack at the ISFSI, concluding:<sup>16</sup>

"Based on these considerations, the dose to the nearest affected resident, from even the most severe plausible threat scenarios – the ground assault and aircraft impact scenarios discussed above – would likely be below 5 rem."

IV-4. That claim was further elaborated in the Staff's August 2007 EA Supplement, which stated at page 7:<sup>17</sup>

"More specifically, NRC staff performed a dose calculation using source term and meteorology inputs from the generic assessments. This resulted in a projected dose of less than 5 rem for the nearest resident. Using the Diablo Canyon site-specific meteorology, as opposed to the generic meteorology, reduces the projected dose consequences by a factor of 10 to 100."

IV-5. In a subsequent response to SLOMFP discovery in this proceeding, the Staff provided additional, but still incomplete, information regarding its estimation of the radiation dose to an individual resident.<sup>18</sup> The Staff stated that dose was calculated as total effective dose (TED) including inhalation, external exposure from the plume, and 4 days of external exposure from deposited material. Presumably, the Staff actually calculated total effective dose equivalent (TEDE). As a first step, the Staff used the

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<sup>16</sup> NRC, 2007b.

<sup>17</sup> NRC, 2007a.

<sup>18</sup> NRC, 2008b, pp 15-17.

Hotspot code assuming a release height of 1 meter, no plume rise, a wind speed of 4.0 meters per second, and atmospheric stability of D (neutral). Given those assumptions, dose was calculated for an individual at an unstated distance. As a second step, the Staff compared the Hotspot-modeled plume dispersion with dispersion estimates provided in the licensee's Environmental Report for the location of the nearest resident to the Diablo Canyon ISFSI, at a distance of 2,414 meters. That step yielded a dose 1 or 2 orders of magnitude lower than did the first step.

IV-6. Hotspot is a code developed by Lawrence Livermore National Laboratory (LLNL). It is a conventional Gaussian straight-line dose assessment model. In describing Hotspot, LLNL says:<sup>19</sup>

"Users requiring more sophisticated modeling capabilities, e.g., complex terrain; multi-location real-time wind field data; etc., are directed to such capabilities as the Department of Energy's NARAC computer codes."

IV-7. The Diablo Canyon site is on the coast, with substantial topographic relief (hills) in landward directions. An atmospheric plume released at such a location can exhibit complex behaviors. The NRC Staff did not attempt to model those behaviors, relying instead on the Hotspot code. The findings of that code could be highly misleading. For example, a study conducted for NRC in 1983 stated, regarding plume behavior in coastal zones:<sup>20</sup>

"The direct application of a conventional Gaussian straight-line dose assessment model, initialized only by on-site tower data, can potentially produce highly misleading guidance as to plume impact locations."

The same study also stated:<sup>21</sup>

"For sites located within a coastal zone the following are just some of the transport phenomena routinely encountered:

- (1) surface wind flow reversals due to mesoscale frontal passages,
- (2) the return of effluents onshore that had previously drifted over water during the prior night's land breeze,
- (3) trajectory curvature due to Coriolis and other forces,
- (4) plume bifurcation from multi-stack releases due to extreme vertical wind shears,
- (5) transport of near surface plumes to higher altitudes due to chimney-like updrafts in convergence zones,
- (6) encapsulation of plumes in return flow layers aloft,
- (7) second trip fumigation from recirculating plumes."

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<sup>19</sup> LLNL, 2008.

<sup>20</sup> Lyons et al, 1983, page 3.

<sup>21</sup> Lyons et al, 1983, pp 5-6.

IV-8. A comprehensive assessment of the environmental impacts of potential attacks on the Diablo Canyon ISFSI would consider the range of plume behaviors that can be exhibited at this particular site. The NRC Staff chose, instead, to use a simple, stylized model of plume behavior – the Hotspot code – despite its known limitations. That approach is consistent with a preconceived view that the environmental impacts of potential attacks are insignificant. A similar approach is evident in the Staff's consideration of attack-induced releases of radioactive material, as discussed in Section VI, below.

#### **V. Attack-Induced Atmospheric Release of Radioactive Material from a Spent-Fuel-Storage Module: Background Discussion**

V-1. There is a published, technical literature that relates, directly and indirectly, to attack-induced atmospheric release of radioactive material from a spent-fuel-storage module of the type that would be used at the Diablo Canyon ISFSI. Also, general attributes of such a release can be estimated from professional knowledge of engineering and related disciplines. In the following paragraphs, these sources are used to discuss the range of attack-induced atmospheric releases that could occur at the Diablo Canyon ISFSI. In Section VI, below, that range is compared with the releases considered by the NRC Staff.

V-2. One example of relevant published literature is a 2001 paper by Lange et al, discussing an experiment to simulate an attack on a cask used for storage or transport of spent fuel, using a shaped charge.<sup>22</sup> The authors described a test, done in 1992, in which a shaped charge penetrated a shortened CASTOR cask containing shortened fuel assemblies in which the pellets were made of depleted uranium. The fuel rods were internally pressurized to 40 bar to simulate real spent-fuel rods. The shaped charge was intended to represent an anti-tank weapon. Each of two shots yielded a release of 1.0 grams of uranium in the aerodynamic equivalent diameter (AED) class of less than 12.5 micrometer, and 2.6 grams in the AED class 12.5 to 100 micrometer. Using these test results, the authors estimated the downwind radiation dose for an equivalent attack on a real cask containing real spent fuel. They estimated that the inhalation dose at a distance of 50 meters would be below 50 mSv (5 rem) for the most severe (i.e., dose-enhancing) weather conditions. The inhalation dose would be dominated by actinides, such as plutonium isotopes.

V-3. There is an International Working Group for Sabotage Concerns of Transport and Storage Casks. This Working Group links SNL, DOE, NRC and organizations in Germany, France and UK. The Working Group conducts an experimental program whose findings are published periodically. One of those publications, dated October 2006, stated at page 3:<sup>23</sup>

"This program provides source-term data that are relevant to some sabotage

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<sup>22</sup> Lange et al, 2001.

<sup>23</sup> Molecke et al, 2006.

scenarios in relation to spent fuel transport and storage casks, and associated risk assessments."

The same publication stated at page 15:

"This experimental program is designed to measure several important features of the interaction of a HEDD (conical shaped charge, CSC) jet with spent fuel or surrogate material pellets contained within a Zircaloy-4 cladding tube."

The term HEDD refers to a high-energy-density device, in the form of a shaped charge. It is clear that the primary focus of the Working Group's experimental program is to examine the creation by an HEDD of respirable aerosol. Information about the release of respirable aerosol is needed to estimate the inhalation dose accrued by an individual downwind of an attacked cask.

V-4. The NRC Staff argues that the radiation dose to a downwind resident following an attack on the Diablo Canyon ISFSI would not exceed 5 rem. Exposure of a person to a dose of 5 rem would require only a small release of radioactive material from a spent-fuel-storage module, as discussed in the report I prepared to support SLOMFP's contentions.<sup>24</sup> That report showed, for example, that creation of a hole in a module's multi-purpose canister (MPC) would yield a dose of 6.3 rem to an individual located 900 meters downwind if the hole had an equivalent diameter of a mere 2.3 mm. Most (95 percent) of the dose would be attributable to the release of two-millionths (1.9E-06) of the MPC's inventory of radioisotopes in the "fines" category. The dose of 6.3 rem would be the committed effective dose equivalent (CEDE) arising from inhalation. CEDE would make up most of the total dose (TEDE) and is a sufficient approximation to it.

V-5. The experiments discussed in paragraphs V-2 and V-3, above, simulated mechanical damage to the interior of a container containing spent fuel assemblies. The damage would encompass some or all of the rods in affected fuel assemblies, and some of the pellets in those rods. These experiments did not investigate the potential for ignition of the zirconium alloy (zircaloy) cladding of the rods, or the implications of that ignition for the release of radioactive material to the atmosphere. Similarly, the calculations summarized in paragraph V-4 did not consider zircaloy ignition. As shown in the following paragraph, ignition of zircaloy cladding could lead to a substantial atmospheric release of cesium-137, causing severe radiological impacts of the type discussed in paragraph II-3, above.

V-6. Table 1 shows that the energy released by combustion of zircaloy cladding in air would be ample to raise the temperature of adjacent fuel pellets well above the boiling point of cesium, which is about 690 degrees C. Sustained combustion inside a spent-fuel-storage module would require the free ingress of air and egress of combustion products. If those conditions prevailed, combustion of cladding could propagate to many of the

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<sup>24</sup> Thompson, 2007b, page 33 and Table 4-1.

rods inside the module, and the release of radioactive material to the atmosphere could include tens of percent of the module's inventory of cesium-137.

V-7. The preceding discussion shows that a thorough investigation of the vulnerability of an ISFSI to attack would devote considerable attention to the potential for ignition and sustained combustion of the zircaloy cladding inside a spent-fuel-storage module. That potential was discussed in the report I prepared to support SLOMFP's contentions.<sup>25</sup>

V-8. One means, among others, whereby a sub-national group could obtain combustion of zircaloy cladding would be to attack a spent-fuel-storage module using a device in which two stages are mounted in tandem. The first stage would be a shaped charge that penetrates the module's overpack and MPC. The second stage would use incendiary material, perhaps combined with explosive material, to ignite the zircaloy cladding. Table 2 shows that shaped charges capable of penetrating a module's overpack and MPC have been widely available for decades. Various types of incendiary material are available, and are described in published literature.<sup>26</sup> Many types of incendiary device have been developed. For example, experts at SNL have described their testing of devices that combined explosive material with combustible metals.<sup>27</sup> These devices yielded blast, fragmentation and incendiary effects in combination. Zirconium sponge was found to function well as an incendiary. A specific purpose of the testing was to prepare for the development of an incendiary warhead for a penetrating device. The tests led to the following conclusion:<sup>28</sup>

"Our results indicate that a metalized incendiary explosive device is feasible and capable of starting massive fires at the target site."

V-9. Small, self-propelled missiles that can be equipped with tandem warheads are available on international arms markets. Consider two Russian-made examples. The RPG-29V has an effective direct-fire range of 300 meters.<sup>29</sup> It is said to be able to penetrate 1.5 meters of reinforced concrete. The Komet E is laser guided.<sup>30</sup> Its range is up to 5.5 kilometers in daylight and 3.5 kilometers at night. The manufacturer claims penetration of 1.2 meters of steel armor or 4.5 meters of concrete. A firing unit including launcher, thermal sight and one missile has a mass of 65 kg.

V-10. Arms manufacturers are continuing to develop tandem-warhead systems. For example, in January 2008 Raytheon tested the shaped-charge penetrating stage for its Tandem Warhead System.<sup>31</sup> The shaped charge penetrated 19 feet into steel-reinforced

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<sup>25</sup> Thompson, 2007b, pp 33-37.

<sup>26</sup> For example, Fischer and Grubelich, 1996b, provided information about various exothermic reactions. These included the "traditional" thermite reaction:  $8\text{Al} + 3\text{Fe}_3\text{O}_4 \rightarrow 4\text{Al}_2\text{O}_3 + 9\text{Fe}$ . The heat of that reaction is 879 cal per gram, and the adiabatic reaction temperature, with phase changes, is 3,135 degrees K = 2,862 degrees C.

<sup>27</sup> Fischer and Grubelich, 1996a.

<sup>28</sup> Fischer and Grubelich, 1996a, page 11.

<sup>29</sup> Defense Update, 2008a.

<sup>30</sup> Defense Update, 2008b.

<sup>31</sup> Raytheon, 2008.

concrete with a compressive strength of 12,600 psi. The purpose of this new system is to penetrate a target protected by concrete, steel and rock barriers, and to cause damage inside the target. Development of the system was self-funded by Raytheon. The current version would have a mass of about 1,000 pounds in its tandem configuration. Raytheon states that it could scale the technology, which implies both larger and smaller versions.

V-11. The preceding discussion in Section V has outlined some of the types of attack-induced atmospheric release that could be experienced by a spent-fuel-storage module at the Diablo Canyon ISFSI. Table 3 provides a more complete description of potential attack-induced atmospheric releases. Four types of release are identified. Without excluding Type I and Type II releases from consideration, I focus here on Type III and Type IV releases. The differences between these releases are significant in the context of the present proceeding. Type III releases would be associated with attack scenarios such as the impact of a commercial aircraft, or the explosion of a vehicle bomb. Scenarios of that type would have a comparatively dramatic appearance, featuring noise, external fire, and smoke. By comparison, the attack scenarios associated with Type IV releases would appear less dramatic. Yet, the Type IV releases would contain much larger amounts of volatile isotopes such as cesium-137, which would be significant from the perspective of land contamination. A superficial assessment of the vulnerability of an ISFSI might lead to the conclusion that Type IV releases deserve less consideration than do Type III releases. That assessment would be incorrect. It would ignore the greater sophistication of the attack scenarios associated with Type IV releases, which would aim to maximize radiological impacts rather than the dramatic appearance of the event. Also, analysts whose attention is focused on the inhalation dose to a downwind individual could fail to appreciate the significance of Type IV releases, if they assume that the more dramatic-appearing attack scenarios associated with Type III releases would yield larger amounts of the isotopes that dominate inhalation dose.<sup>32</sup>

#### **VI. Attack-Induced Atmospheric Release of Radioactive Material from a Spent-Fuel-Storage Module: Consideration by the NRC Staff**

VI-1. The NRC Staff has not disclosed any information about the attack-induced atmospheric releases that it has considered in the context of the Diablo Canyon ISFSI. Some information about those releases can, however, be inferred from available sources, as described below.

VI-2. The Staff has disclosed some information about a study conducted for NRC by SNL, regarding the impact of a large aircraft on a field of HI-STORM spent-fuel-storage modules. That type of module would be used at the Diablo Canyon ISFSI. The study was described in a report.<sup>33</sup> Most of the content was redacted from the version of the report provided to SLOMFP. At page 7, the redacted report stated that the mass of the assumed aircraft is representative of the class of aircraft involved in the 9/11 events. At pages 24-25, the report stated that it is unlikely that a pool of fuel and a storage module

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<sup>32</sup> Note that cesium-137 in an atmospheric plume would be significant from the perspective of land contamination, but would yield a comparatively small dose if inhaled.

<sup>33</sup> Smith et al, 2004.

would be co-located after the dynamic phase of the impact had concluded. Thus, a long-duration pool fire affecting a module was judged to be a non-credible event. At page C-4, the report mentioned the analytic simulation of a quiescent, engulfing fire affecting an upright module. The simulation was run for a short time – 90 to 180 seconds – consistent with SNL's judgment that a module would not be co-located with a long-duration pool fire.

VI-3. Another report described a study conducted by SNL for NRC on the response of a HI-STORM 100 module to an explosive blast.<sup>34</sup> Again, most of the content was redacted from the version provided to SLOMFP. At page 8 the redacted report stated:

"The amount of explosive and standoff distance is representative of a scenario of a small truck parked directly adjacent to the cask. The scenario parameters for this event were defined by NRC design basis threat criteria and by NRC staff, where more specificity was required to define the event. This loading simulates a truck delivery of the explosive, parked adjacent to the cask."

At page 21 the report stated:

"The charge configuration is limited to a bare TNT charge in close proximity to the cask."

VI-4. The attack scenarios discussed in paragraphs VI-2 and VI-3 would be associated with Type III atmospheric releases, using the typology set forth in Table 3. Both scenarios would have a dramatic appearance, but neither would represent a sophisticated approach to maximizing radiological impacts. Neither scenario would be likely to initiate sustained combustion of zircaloy cladding inside a module. Both scenarios would be consistent with atmospheric releases similar to those discussed in paragraphs V-2 to V-4, above. For such releases, the dominant radiological impact would be the inhalation doses accrued by persons exposed to the radioactive plume.

VI-5. The NRC Staff argues that the environmental impacts of potential attacks on the Diablo Canyon ISFSI are not significant. The Staff has not provided a comprehensive assessment to support that position.<sup>35</sup> Nor has the Staff disclosed all of the assumptions that underlie its position. Thus, much of the basis for the Staff's position remains hidden. Section III of this testimony provides compelling evidence that NRC has made a policy choice to consider only one category of environmental impacts, namely the potential for early fatalities. That policy choice, and other factors, could provide a four-part explanation of how the Staff reached its position on environmental impacts, as follows. First, the policy choice would have prevented the Staff from considering any category of environmental impacts other than the potential for early fatalities. Second, as an outcome of the policy choice, the Staff would have focused its attention on the inhalation dose to a

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<sup>34</sup> Kipp et al, 2004.

<sup>35</sup> As discussed in paragraph II-5, a comprehensive assessment would consider a range of attack scenarios, release types, and weather conditions. It would also address site-specific issues, including the complexities of atmospheric plume dispersion at the Diablo Canyon site.

downwind individual, because that mode of radiation exposure would be most likely to lead to an early fatality. Third, as an outcome of focusing on inhalation dose, the Staff would have believed that Type IV releases do not require consideration, because the Staff thought that Type III releases would include larger or comparable amounts of the isotopes that dominate inhalation dose. Fourth, the Staff would have been misled by the comparatively dramatic appearance of the attack scenarios associated with Type III releases, leading to the false conclusion that Type IV releases would yield comparatively small environmental impacts.

VI-6. The four-part process described in the preceding paragraph is consistent with all of the information provided by the Staff in this matter. I am not aware of any better explanation of the Staff's position on environmental impacts of potential attacks. The most prominent feature of this explanation is that the Staff began its assessment of the environmental impacts of an attack on the Diablo Canyon ISFSI with a preconceived position. As a result, the Staff did not conduct a comprehensive, science-based assessment, and its conclusions were faulty. The process is reminiscent of the Staff's prolonged failure to understand the potential for ignition of spent fuel in a high-density spent-fuel pool, if water were lost from the pool.<sup>36</sup> In a license proceeding regarding the Harris nuclear power plant, I argued that comparatively aged spent fuel – including fuel aged 10 or more years after discharge from a reactor – could ignite if water were lost. The Staff disparaged my position, but subsequently adopted that position. For almost two decades, the Staff had failed to understand that comparatively aged fuel could ignite. The Staff's prolonged failure derived from an erroneous, preconceived position, namely that total, instantaneous loss of water would be the most severe mode of loss of water.

## **VII. Conclusions**

VII-1. The NRC Staff has not conducted a comprehensive, science-based assessment to support its position that the environmental impacts of potential attacks on the Diablo Canyon ISFSI are not significant. Instead, the Staff conducted a limited assessment that led to an erroneous conclusion. There is compelling evidence that the assessment was shaped by a preconceived position. A major determinant of that position was an NRC policy choice to consider only one category of environmental impacts, namely the potential for early fatalities. It appears that the Staff was also misled by other factors, including the comparatively dramatic appearance of attack scenarios that the Staff chose to consider. A comprehensive assessment of environmental impacts would consider additional attack scenarios, together with a range of radiological impacts including land contamination and its sequelae.

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<sup>36</sup> Thompson, 2007d, pp 4-5.

I declare under penalty of perjury under the laws of the United States of America that the foregoing statements of fact are true and correct to the best of my knowledge and belief, and that the opinions expressed herein are based on my best professional judgment.

Executed on 14 April 2008.



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Gordon R. Thompson, D.Phil

Canberra, Australia

NOTE: The bibliography and the three tables that appear on the following pages are discussed in the narrative sections above, and are part of this declaration.

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**Table 1**  
**Illustrative Calculation of Heat-Up of a Fuel Rod in a PWR Fuel Assembly Due to Combustion in Air**

Indicator	Affected Material	
	Zircaloy Cladding	UO <sub>2</sub> Pellets
Solid volume, per m length	1.90E-05 cub. m (OD = 1.07 cm; thickness = 0.06 cm)	6.36E-05 cub. m (OD = 0.9 cm)
Mass, per m length	0.124 kg (@ 6.55 Mg per cub. m)	0.700 kg (@ 11.0 Mg per cub. m)
Heat output from combustion of material in air, per m length	1.48 MJ (@ 2,850 cal per g Zr)	Neglected
Equilibrium temperature rise if material receives 50% of heat output from adjacent combustion, and if heat loss from material is neglected	Neglected	approx. 2,700 deg. C (enthalpy rise if UO <sub>2</sub> temp. rises from 300 K to 3,000 K = 1,052 kJ per kg UO <sub>2</sub> )

**Notes:**

(a) Data shown in table are from: Nero, 1979, Table 5-1; Powers et al, 1994, Table 4; and files accessed at International Nuclear Safety Center (INSC), Argonne National Laboratory, <<http://www.insc.anl.gov/>>, in March 2008.

(b) Melting point of UO<sub>2</sub> is 2,850 deg. C (from INSC files).

(c) Boiling point of elemental cesium is 685 deg. C (from: Thompson and Beckerley, 1973, Volume 2, page 527).

(d) 1 cal = 4.184 J

**Table 2**  
**Performance of US Army Shaped Charges, M3 and M2A3**

Target Material	Indicator	Type of Shaped Charge	
		M3	M2A3
Reinforced concrete	Maximum wall thickness that can be perforated	60 in	36 in
	Depth of penetration in thick walls	60 in	30 in
	Diameter of hole	• 5 in at entrance • 2 in minimum	• 3.5 in at entrance • 2 in minimum
	Depth of hole with second charge placed over first hole	84 in	45 in
Armor plate	Perforation	At least 20 in	12 in
	Average diameter of hole	2.5 in	1.5 in

**Notes:**

- (a) Data are from: Army, 1967, pp 13-15 and page 100.
- (b) The M2A3 charge has a mass of 12 lb, a maximum diameter of 7 in, and a total length of 15 in including the standoff ring.
- (c) The M3 charge has a mass of 30 lb, a maximum diameter of 9 in, a charge length of 15.5 in, and a standoff pedestal 15 in long.

**Table 3**  
**Types of Atmospheric Release from a Spent-Fuel-Storage Module at the Diablo Canyon ISFSI as a Result of a Potential Attack**

Type of Event	Module Behavior	Relevant Instruments and Modes of Attack	Characteristics of Atmospheric Release
Type I: Vaporization	<ul style="list-style-type: none"> <li>• Entire module is vaporized</li> </ul>	<ul style="list-style-type: none"> <li>• Module is within the fireball of a nuclear-weapon explosion</li> </ul>	<ul style="list-style-type: none"> <li>• Radioactive content of module is lofted into the atmosphere and amplifies fallout from nuc. explosion</li> </ul>
Type II: Rupture and Dispersal (Large)	<ul style="list-style-type: none"> <li>• MPC and overpack are broken open</li> <li>• Fuel is dislodged from MPC and broken apart</li> <li>• Some ignition of zircaloy fuel cladding may occur, without sustained combustion</li> </ul>	<ul style="list-style-type: none"> <li>• Aerial bombing</li> <li>• Artillery, rockets, etc.</li> <li>• Effects of blast etc. outside the fireball of a nuclear weapon explosion</li> </ul>	<ul style="list-style-type: none"> <li>• Solid pieces of various sizes are scattered in vicinity</li> <li>• Gases and small particles form an aerial plume that travels downwind</li> <li>• Some release of volatile species (esp. cesium-137) if incendiary effects occur</li> </ul>
Type III: Rupture and Dispersal (Small)	<ul style="list-style-type: none"> <li>• MPC and overpack are ruptured but retain basic shape</li> <li>• Fuel is damaged but most rods retain basic shape</li> <li>• No combustion inside MPC</li> </ul>	<ul style="list-style-type: none"> <li>• Vehicle bomb</li> <li>• Impact by commercial aircraft</li> <li>• Perforation by shaped charge</li> </ul>	<ul style="list-style-type: none"> <li>• Scattering and plume formation as for Type II event, but involving smaller amounts of material</li> <li>• Little release of volatile species</li> </ul>
Type IV: Rupture and Combustion	<ul style="list-style-type: none"> <li>• MPC is ruptured, allowing air ingress and egress</li> <li>• Zircaloy fuel cladding is ignited and combustion propagates within the MPC</li> </ul>	<ul style="list-style-type: none"> <li>• Missiles with tandem warheads</li> <li>• Close-up use of shaped charges and incendiary devices</li> <li>• Thermic lance</li> <li>• Removal of overpack lid</li> </ul>	<ul style="list-style-type: none"> <li>• Scattering and plume formation as for Type III event</li> <li>• Substantial release of volatile species, exceeding amounts for Type II release</li> </ul>