

Comment Set CC6, cont.

**San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
(the "Joint Parties")**

Joint Parties' Comments on the DCPP SGRP DEIR

EXHIBIT C

TESTIMONY OF GORDON THOMPSON

ON BEHALF OF THE SAN LUIS OBISPO MOTHERS FOR PEACE,

SIERRA CLUB, PUBLIC CITIZEN, GREENPEACE

AND ENVIRONMENT CALIFORNIA

August 3, 2004

Comment Set CC6, cont.

**San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
(the "Joint Parties")**

Application No.: 04-01-009
Exhibit No.: _____
Date: August 3, 2004
Witness: Gordon Thompson

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA**

Application of Pacific Gas and Electric Company (U 39 E) for
Authority to Increase Revenue Requirements to Recover the
Costs to Replace Steam Generators in Units 1 and 2 of the
Diablo Canyon Power Plant.

Application 04-01-009
(Filed January 9, 2004)

**TESTIMONY OF GORDON THOMPSON
ON BEHALF OF THE SAN LUIS OBISPO MOTHERS FOR PEACE, SIERRA
CLUB, PUBLIC CITIZEN, GREENPEACE AND ENVIRONMENT CALIFORNIA**

Dian M. Grueneich, J.D.
Theresa Cho, Of Counsel
Clyde Murley, M.A.
GRUENEICH RESOURCE ADVOCATES
582 Market Street
San Francisco, CA 94104
(415) 834-2300
(415) 834-2310 facsimile
dgrueneich@gralegal.com
cmurley@gralegal.com

For:

SAN LUIS OBISPO MOTHERS FOR PEACE,
SIERRA CLUB, PUBLIC CITIZEN,
GREENPEACE AND ENVIRONMENT
CALIFORNIA

August 3, 2004

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1 | **I. INTRODUCTION**

2 | Q. Please state your name, business address, and professional affiliations.

3 | A. I am Gordon Thompson. I am the executive director of the Institute for Resource and
4 | Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. The
5 | IRSS office is located at 27 Ellsworth Avenue, Cambridge, MA 02139. IRSS was
6 | founded in 1984 to conduct technical and policy analysis and public education, with the
7 | objective of promoting peace and international security, efficient use of natural resources,
8 | and protection of the environment. In addition to working at IRSS, I hold an appointment
9 | as a research professor at the George Perkins Marsh Institute, Clark University, Worcester,
10 | MA.

11 | Q. Please describe your professional and academic background.

12 | A. I received an undergraduate education in science and mechanical engineering at the
13 | University of New South Wales, in Australia. Subsequently, I received a Doctorate of
14 | Philosophy in mathematics in 1973 from Oxford University, for analyses of plasmas
15 | undergoing thermonuclear fusion. During my graduate studies I was associated with the
16 | fusion research program of the United Kingdom Atomic Energy Authority. My
17 | undergraduate and graduate work provided me with a rigorous education in the
18 | methodologies and disciplines of science, mathematics, and engineering. Since 1977, a
19 | significant part of my work has consisted of technical analyses of safety, security and
20 | environmental issues related to nuclear facilities. These analyses have been sponsored by a
21 | variety of non-governmental organizations and local, state and national governments,
22 | predominantly in North America and Western Europe. Drawing upon these analyses, I
23 | have provided expert testimony in legal and regulatory proceedings, and have served on

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1 committees advising United States government agencies. My Curriculum Vitae is provided
2 here as Appendix A.

3 Q. Please summarize your experience that is relevant to this testimony.

4 A. My analyses of security threats to nuclear facilities, and of options for defending these
5 facilities, have withstood critical scrutiny and affected policy in Europe and the US. For
6 example, my assessment in 1978-1979 of security threats and defense options related to the
7 proposed Gorleben facility in Germany was accepted by the licensing authority, leading to
8 new design standards that remain in effect. Similar assessments that I conducted in relation
9 to the Sellafield site in the UK and the La Hague site in France, at various times between
10 1977 and 2000, have led to new design standards and government policies. My analyses
11 of security threats and defense options related to storage of spent fuel from US nuclear
12 power plants are currently influencing the development of national policy.

13 Q. What is the purpose of your testimony?

14 A. My testimony has two purposes. The first purpose is to show that, given present trends, it
15 is reasonable and prudent to assume that the Diablo Canyon nuclear power plant and its
16 spent fuel will receive an enhanced defense during the coming years. By enhanced defense,
17 I mean the implementation of defensive measures additional to those currently required by
18 the US Nuclear Regulatory Commission (NRC).¹ The testimony's second purpose is to
19 provide an estimate of additional costs to Pacific Gas and Electric (PG&E) that could arise
20 from the provision of the enhanced defense. PG&E has not included such costs in its

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¹ Here, I use the term "defense" in its military sense. In a military context, the term "defense in depth" refers to a set of mutually-supportive but independent measures that protect a facility from external or internal attackers. Some safety experts in the nuclear power industry have appropriated the term defense in depth to refer to the provision of multiple safety systems. I use the term in its original, military sense.

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1 application. Consideration of these costs affects the cost/benefit analyses related to
2 replacement of the Diablo Canyon steam generators.

3 Q. Please briefly summarize your testimony.

4 A. This testimony has nine sections. After this introduction (Section I), Section II describes the
5 Diablo Canyon nuclear power plant. Section III discusses the defense of nuclear power
6 plants in the context of US national security. Section IV reviews the NRC's present
7 requirements for defense of nuclear power plants. That review is followed, in Section V, by
8 a discussion of the risk of attack on nuclear power plants and their spent fuel. In this
9 context, the concept of risk encompasses vulnerability to attack, and the probability and
10 consequences of attack. Section VI describes trends that are leading toward enhanced
11 defense of US nuclear power plants and spent fuel. Section VII describes the type of
12 enhanced defense of the Diablo Canyon plant and its spent fuel that, I believe, it is
13 reasonable and prudent to assume will be implemented in the future. The costs of
14 implementing the additional defensive measures are estimated in Section VIII. My
15 conclusions are set forth in Section IX. Appendix B is a bibliography to support this
16 testimony. Literature cited in the testimony appears in the bibliography.

17 This testimony discusses potential destructive attacks, at the Diablo Canyon plant and other
18 nuclear facilities, that could cause great public harm. No information is contained in the
19 testimony that could assist the perpetrator of such an attack. Accordingly, this testimony is
20 appropriate for general distribution.

21 ///

22 ///

23 **II. THE DIABLO CANYON NUCLEAR POWER PLANT**

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1 Q. Please describe the Diablo Canyon nuclear power plant.

2 A. The Diablo Canyon plant has two nuclear generation units. These units employ essentially
3 identical pressurized-water reactors (PWRs), each rated at a nominal 1,100 MWe. The
4 two units share an auxiliary building and some components of auxiliary systems. Each
5 reactor has a dedicated fuel-handling system and one spent-fuel pool. The reactors were
6 furnished by Westinghouse. Unit 1 began commercial operation in May 1985 and Unit 2 in
7 March 1986. The operating licenses expire in September 2021 for Unit 1 and April 2025
8 for Unit 2.²

9 Q. Please describe the storage facilities for spent fuel.

10 A. The two spent-fuel pools at Diablo Canyon were originally equipped with low-density
11 racks, so that each pool could accommodate one and one-third cores of spent fuel. Each
12 reactor core contains 193 fuel assemblies. In the late 1980s, the low-density racks were
13 replaced by high-density racks that are currently in use. Each pool can now accommodate
14 1,324 spent fuel assemblies. Each unit operates on an 18-21 month refueling cycle and
15 discharges 76-96 spent fuel assemblies per refueling. As of December 2001, each unit had
16 operated for 10 cycles. It follows that each spent-fuel pool contained 760-960 spent fuel
17 assemblies in December 2001. Thus, given a pool capacity of 1,324 assemblies, while
18 allowing space for a full-core offload of 193 assemblies, each pool could, as of December
19 2001, accommodate an additional 171-371 assemblies beyond the assemblies then stored
20 in the pool. PG&E has projected that each pool can accommodate a full-core offload and
21 the accumulated inventory of discharged fuel until 2006.³

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² PG&E, 2001, page 1.1-1.

³ PG&E, 2001, page 1.1-1.

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1 Q. What are PG&E's plans for storage of spent fuel assemblies produced at the Diablo
2 Canyon plant after 2006?

3 A. To accommodate spent fuel discharged from Units 1 and 2 after the pools are full, PG&E
4 has applied for permits from the NRC, San Luis Obispo County, and the California Coastal
5 Commission to establish an independent spent-fuel storage installation (ISFSI) on the
6 Diablo Canyon plant site. This facility would hold up to 140 dry-storage casks, employing
7 the Holtec HI-STORM 100 cask system. PG&E expects that most of the casks would be
8 capable of holding 32 fuel assemblies per cask. Assuming 140 casks each holding 32
9 assemblies, the proposed ISFSI could accommodate 4,480 spent fuel assemblies. PG&E
10 projects that this storage capacity would be sufficient to hold all the spent fuel discharged by
11 Diablo Canyon Units 1 and 2 through the duration of their present operating license terms
12 (2021 for Unit 1 and 2025 for Unit 2).⁴

13 PG&E plans to build the ISFSI in increments. The storage casks would sit on concrete
14 pads, 20 casks per pad in a 4 by 5 array. Initially, two pads would be built.⁵ Ultimately,
15 seven pads would be built side by side, covering an area about 500 feet by 105 feet.
16 PG&E expects that spent fuel would be transferred from the pools to the ISFSI after at
17 least 5 years of storage in the pools. Specifically, casks would be installed as needed to
18 accommodate the spent fuel that would be removed from the pools in order to free up
19 space in the pools for storage of fuel discharged from the reactors.⁶ Thus, from 2006
20 through the present Unit 1 and 2 operating license terms, the pools would hold spent fuel at

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⁴ PG&E, 2001, page 1.2-2.

⁵ PG&E, 2001, page 3.1-1.

⁶ PG&E, 2001, page 1.2-1.

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1 nearly their full capacity. After 2006, the average post-discharge age of the spent fuel in
2 each pool would be about 10 years.

3 Each cask in the planned ISFSI would be about 11 feet in diameter and 20 feet high. The
4 surface-to-surface distance between casks would be about 6 feet. The ISFSI's full capacity
5 of 140 casks would be achieved by placing casks in a 5 by 28 array. A security fence
6 would surround the area needed for this array, at a distance of about 50 ft from the
7 outermost casks. That fence would in turn be surrounded by a second fence, at a distance
8 of about 100 feet from the outermost casks.⁷

9 The HI-STORM 100 dry-cask storage system employs a multi-purpose canister (MPC)
10 that contains the fuel, and a storage overpack that surrounds the MPC during storage. The
11 MPC is a thin-walled stainless-steel cylinder containing a basket structure to hold the spent
12 fuel assemblies. After the MPC receives fuel and is sealed, it is filled with helium. The
13 overpack is a thick-walled concrete cylinder whose surfaces are clad with a thin coating of
14 carbon steel. Cooling of the MPC occurs by natural circulation of ambient air in a space
15 between the MPC and the overpack. This air enters the overpack through holes near its
16 base, passes over the MPC, and leaves the overpack through holes near its top.⁸

17 Q. Was PG&E aware of the need for additional on-site, spent-fuel storage capacity when the
18 NRC approved construction of the Diablo Canyon plant?

19 A. No. The long-term, on-site storage of spent fuel at the Diablo Canyon plant was never
20 considered because it was assumed that the waste would be transported to an off-site
21 facility.

⁷ PG&E, 2001, Chapter 3.

⁸ PG&E, 2001, Chapter 3.

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1 Q. Please describe the inventory of radioactivity that will be present in spent fuel at the site.
2 A. Each fuel assembly contains a variety of radioactive isotopes, but one isotope --cesium-137
3 -- is especially useful as an indicator of the potential for radiological harm. Cesium-137 is a
4 radioactive isotope with a half-life of 30 years. This isotope accounts for most of the offsite
5 radiation exposure that is attributable to the 1986 Chernobyl reactor accident, and for about
6 half of the radiation exposure that is attributable to fallout from testing nuclear weapons in
7 the atmosphere.⁹ Cesium is a volatile element that would be liberally released during the
8 meltdown of a reactor core or during a fire in a drained spent-fuel pool.
9 The inventory of cesium-137 in the Diablo Canyon plant pools or the proposed ISFSI can
10 be readily estimated. Three parameters govern the estimate -- the number of spent fuel
11 assemblies, their respective burnups, and their respective ages after discharge. I have made
12 such estimates, assuming a representative, uniform burnup of 46 gigawatt-days per tonne.¹⁰
13 As a separate exercise, I have estimated the inventory of cesium-137 in the Diablo Canyon
14 reactors.
15 PG&E projections indicate that each of the Diablo Canyon plant pools will contain, from
16 2006 until the 2020s and potentially beyond, an inventory of spent fuel approaching the
17 pool's capacity of 1,131 assemblies. The average post-discharge age of the fuel will be
18 about 10 years. This inventory of spent fuel -- 1,131 assemblies aged for 10 years -- will
19 contain about 56 million Curies (630 kilograms) of cesium-137. For comparison, the core
20 of each Diablo Canyon reactor contains about 6 million Curies (67 kilograms) of cesium-
21 137. At the proposed Diablo Canyon ISFSI, one cask containing 32 fuel assemblies with

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⁹ DOE, 1987.

¹⁰ Burnup is the cumulative fission energy released in a fuel assembly during its period of use.

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1 an average post-discharge age of 20 years would contain about 1.3 million Curies (14
2 kilograms) of cesium-137.

3 As a comparison, the Chernobyl reactor accident of 1986 released about 2.4 million Curies
4 (27 kilograms) of cesium-137 to the atmosphere. That release represented 40 percent of
5 the Chernobyl reactor core's inventory of 6 million Curies (67 kilograms) of cesium-137.¹¹

6 Atmospheric testing of nuclear weapons led to the deposition of about 20 million Curies
7 (220 kilograms) of cesium-137 across the land and water surfaces of the Northern
8 Hemisphere.¹²

9 **III. NUCLEAR POWER PLANTS AND NATIONAL SECURITY**

10 Q. Please describe the security threat to nuclear power plants and their spent fuel.

11 A. The National Strategy for The Physical Protection of Critical Infrastructures and Key
12 Assets, which was published in February 2003, identifies nuclear power plants as key
13 assets, defined as follows:¹³

14 "Key assets represent individual targets whose destruction could cause large-
15 scale injury, death, or destruction of property, and/or profoundly damage our
16 national prestige, and confidence".

17 Prominent officials, such as the Chair of the National Intelligence Council, Robert Hutchings,
18 have concurred on the security threat posed by nuclear power plants:¹⁴

19 Targets such as nuclear power plants, water treatment facilities, and other public
20 utilities are high on al-Qa'ida's targeting list as a way to sow panic and hurt our
21 economy. . . . Just this past year, al-Qa'ida attacks in Kenya, Saudi Arabia,
22 and Turkey have demonstrated the group's impressive expertise to build truck
23 bombs, and we are concerned it will try to marry this capability to toxic or
24 radioactive material to increase the damage and psychological impact of an

¹¹ Krass, 1991.

¹² DOE, 1987.

¹³ White House, 2003, page 7.

¹⁴ Hutchings, 2004.

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1 attack. . . . I have already detailed the terrorist threat and feel it is important to
2 point out that according to State Department statistics, more businesses are
3 targeted in terrorist attacks than all other types of facilities combined. US
4 interests both abroad and at home, as well as US citizens working abroad, are
5 prime targets for terrorist groups seeking to damage the US economy and affect
6 our way of life. High-profile facilities such as nuclear power plants, oil and gas
7 production, and export and receiving facilities remain at risk; moreover al-
8 Qa'ida and other terrorist groups' targets and methods may be evolving.

9 Q. In your opinion, is the concern expressed by Chairman Hutchings justified?

10 A. Yes. Nuclear power plants and their spent fuel are, in my opinion, likely targets in a
11 sophisticated attack on the US homeland, for both symbolic and practical reasons. An
12 important symbolic reason is the connection of nuclear power plants with nuclear weapons.
13 The US government justified its March 2003 invasion of Iraq in large part by the possibility
14 that the Iraqi government might have acquired a nuclear weapon. Yet, our government
15 flaunts its own superiority in nuclear weapons and rejects the constraint of its weapons by
16 international agreements such as the Non-Proliferation Treaty.¹⁵ As an approach to
17 international security, this policy has been criticized by the director general of the
18 International Atomic Energy Agency as "unsustainable and counterproductive".¹⁶
19 It would be prudent to assume that this policy will motivate terrorist groups to respond
20 asymmetrically to US nuclear superiority, possibly through an attack on a US nuclear power
21 plant and/or its spent fuel. From a practical perspective, nuclear power plants and ISFSIs
22 are large, fixed targets. At present, as shown below, these facilities are lightly defended. In
23 the eyes of an enemy, they can be regarded as pre-deployed radiological weapons that
24 could release large amounts of radioactive material.

¹⁵ Deller, 2002; Scarry, 2002.

¹⁶ ElBaradei, 2004, page 9.

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1 An attack on a US nuclear facility would be either an act of insanity or an act of malice. An
2 insane attacker would have no political purpose, but a malicious attacker would be pursuing
3 the political objectives of a domestic or foreign constituency. Currently, concern about
4 attack is focused on foreign enemies and their domestic sympathizers. These groups are not
5 the only sources of threat, but they deserve special consideration because their objectives
6 relate to US foreign policy and military campaigns.

7 Q. What general actions can be taken in response to the threat of a foreign-origin attack?

8 A. There should be a mixture of offensive and defensive actions. "Offensive" refers to efforts
9 to destroy or incapacitate attackers before they attack, and "defensive" refers to protecting
10 ourselves from attack. The need for a balance between offensive and defensive actions was
11 recognized by a task force convened by the Council on Foreign Relations. In an October
12 2002 report, this group stated:¹⁷

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

21 Q. How would you describe the current level of defensive action at nuclear facilities?

22 A. The NRC requires only a light defense for civilian nuclear facilities. It does not require
23 security measures that reflect the actual security risks. The NRC is, in effect, rejecting the
24 advice of the Council on Foreign Relations' task force that I quote above. An explicit

¹⁷ Hart et al, 2002, pp 14-15.

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1 rejection of this type of advice was articulated by the NRC chair, Richard Meserve, in late
2 2002:¹⁸

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

10 Q. Do you agree with this statement?

11 A. No. To deter attack, the nation need not scrap every modern technology or infrastructure
12 asset. Instead, potential targets can be ranked by their attractiveness as targets for attack.
13 Then, each target can receive a level of defense that is commensurate with its attractiveness.
14 The chosen level of defense would aim to reduce the likelihood of a successful attack and
15 the consequences of an attack. In instances where the cost of providing the chosen level of
16 defense appears prohibitive, the target can be replaced by another, more defensible, facility
17 or activity that serves the same purpose.

18 Q. What is the significance of the NRC's approach to security at nuclear facilities?

19 A. Without any public debate, and apparently without any analysis of strategic risks, the NRC
20 has chosen to rely primarily on US offensive capabilities to protect nuclear power plants.

21 Q. Do you believe that this is an adequate approach?

22 A. No. As discussed above, defensive capabilities are equally important. In addition, the US
23 government's offense-dominated response to terrorism has proven to be costly in terms of
24 fracturing alliances and arousing hostility worldwide. If anything, this offensive approach has
25 increased the risks of terrorist attack in the US. Drawing a balance between defending key

¹⁸ Meserve, 2002a, page 22.

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1 assets and pursuing security through offensive actions is a crucial, but not always
2 understood, aspect of homeland-security policy.

3 **IV. PRESENT NRC REQUIREMENTS FOR DEFENSE OF NUCLEAR POWER**
4 **PLANTS**

5 Q. Briefly describe the history of government regulation of security at nuclear power plants.

6 A. The NRC's basic policy on the protection of nuclear facilities from attack is set forth in 10
7 Code of Federal Regulations (CFR) § 50.13. This regulation was originally promulgated in
8 September 1967 by the US Atomic Energy Commission (AEC), the predecessor of the
9 NRC. It states:¹⁹

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

17 Q. Has this policy changed over time?

18 A. Regulation 10 CFR 50.13 remains in effect.²⁰ Nevertheless, experience has forced the
19 NRC to increase licensees' obligations to defend nuclear facilities. A series of events,
20 including the 1993 bombing of the World Trade Center in New York, forced the NRC to
21 introduce a rule in 1994, requiring licensees to defend nuclear power plants against vehicle
22 bombs.²¹ The terrorist events of September 11, 2001 have forced the NRC to require

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¹⁹ Federal Register, Vol. 32, No. 186, 26 September 1967, page 13445.

²⁰ Regulation 10 CFR 50.13 does not preclude the US government from defending nuclear power plants. Indeed, the NRC chair has stated (Meserve, 2002a, page 22) that defense of nuclear plants against air attack would, if required, be a task for the US military.

²¹ Final Rule, Protection Against Malevolent Use of Vehicles at Nuclear Power Plants, 59 Fed. Reg. 38,889 (August 1, 1994).

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1 additional measures, described below. Yet, as shown below, the NRC currently requires
2 only a light defense of nuclear facilities.

3 Q. What was the NRC's response to the events of September 11, 2001?

4 A. After the events of September 11, the NRC concluded that its requirements for nuclear-
5 facility security were inadequate. Accordingly, the NRC issued an order to licensees of
6 operating plants in February 2002, and similar orders to licensees of decommissioning
7 plants in May 2002 and reactor-site ISFSI licensees in October 2002, requiring "certain
8 compensatory measures", also described as "prudent, interim measures", whose purpose
9 was to "provide the Commission with reasonable assurance that the public health and safety
10 and common defense and security continue to be adequately protected in the current
11 generalized high-level threat environment".²² The additional measures required by these
12 orders were not publicly disclosed, but the NRC chair stated that they included:²³

- 13 (i) increased patrols;
- 14 (ii) augmented security forces and capabilities;
- 15 (iii) additional security posts;
- 16 (iv) vehicle checks at greater stand-off distances;
- 17 (v) enhanced coordination with law enforcement and military authorities;
- 18 (vi) additional restrictions on unescorted access authorizations;
- 19 (vii) plans to respond to plant damage from explosions or fires; and
- 20 (viii) assured presence of Emergency Plan staff and resources.

²² The quoted language is from page 2 of the NRC's order of February 25, 2002 to all operating power reactor licensees. Almost-identical language appears in the NRC's orders of May 23, 2002 to all decommissioning power reactor licensees and October 16, 2002 to all ISFSI licensees who also hold 10 CFR 50 licenses.

²³ Meserve, 2002b.

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1 The NRC also established a Threat Advisory System that warns of a possible attack on a
2 nuclear facility. This system uses five color-coded threat conditions ranging from green (low
3 risk of attack) to red (severe risk of attack). These threat conditions conform with those
4 used by the Department of Homeland Security.

5 Q. What types of defensive measures does the NRC require?

6 A. Present NRC requirements for the defense of nuclear facilities are focused primarily on site
7 security, which the NRC discusses under the heading "physical protection". As described in
8 Section VII, below, site security is one of four types of measures that, taken together, could
9 provide a defense in depth against acts of malice or insanity. The other three types of
10 measures are: facility robustness; damage control; and emergency response planning. With
11 some limited exceptions, these measures are ignored in present NRC requirements for
12 nuclear-facility defense.²⁴

13 Q. What is meant by "physical protection" in terms of NRC security requirements?

14 A. At a nuclear power plant or an ISFSI, the NRC requires the licensee to implement a set of
15 physical protection measures. According to the NRC, these measures provide defense in
16 depth by taking effect within defined areas with increasing levels of security. Within the
17 outermost physical protection area, known as the Exclusion Area, the licensee is expected
18 to control the area but is not required to employ fences and guard posts for this purpose.
19 Within the Exclusion area is a Protected Area encompassed by physical barriers including
20 one or more fences, together with gates and barriers at points of entry. Authorization for
21 unescorted access within the Protected Area is based on background and behavioral

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1 checks. Within the Protected Area are Vital Areas and Material Access Areas that are
2 protected by additional barriers and alarms; unescorted access to these locations requires
3 additional authorization.

4 Associated with the physical protection areas are measures for detection and assessment of
5 an intrusion, and for armed response to an intrusion. Measures for intrusion detection
6 include guards and instruments whose role is to detect a potential intrusion and notify the site
7 security force. Then, security personnel seek additional information through means such as
8 direct observation and closed-circuit TV cameras, to assess the nature of the intrusion. If
9 judged appropriate, an armed response to the intrusion is then mounted by the site-security
10 force, potentially backed up by local law-enforcement agencies and the FBI. The design of
11 physical protection areas and their associated barriers, together with the design of measures
12 for intrusion detection, intrusion assessment and armed response, is required to
13 accommodate a "design basis threat" (DBT) specified by the NRC.

14 Q. What is a DBT?

15 A. A DBT is a set of characteristics of a potential attack on a nuclear facility. It provides a
16 basis for the design and assessment of defensive measures. At a nuclear power plant, the
17 dominant sources of hazard are the reactor(s) and the spent-fuel pool(s). In theory, both of
18 these items receive the same level of protection against attack, but in
19 practice the reactor has been the main focus of attention. The DBT for an ISFSI is less
20 demanding than that for a nuclear power plant.

21 Q. What is the DBT for a nuclear power plant?

²⁴ For information about the NRC's requirements – expressed in regulations, rules and orders -- for nuclear-facility defense, see: the NRC website (www.nrc.gov); Markey, 2002; Meserve, 2002b; Meserve, 2003; and

Comment Set CC6, cont.

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1 A. In April 2003 the DBT for a nuclear power plant was revised, but the NRC announced that
2 the features of the revised DBT would not be published. The previously-applicable DBT
3 had the following features:²⁵

4 "(i) A determined violent external assault, attack by stealth, or deceptive
5 actions, of several persons with the following attributes, assistance and
6 equipment: (A) Well-trained (including military training and skills) and dedicated
7 individuals, (B) inside assistance which may include a knowledgeable individual
8 who attempts to participate in a passive role (e.g., provide information), an
9 active role (e.g., facilitate entrance and exit, disable alarms and communications,
10 participate in violent attack), or both, (C) suitable weapons, up to and including
11 hand-held automatic weapons, equipped with silencers and having effective long
12 range accuracy, (D) hand-carried equipment, including incapacitating agents and
13 explosives for use as tools of entry or for otherwise destroying reactor, facility,
14 transporter, or container integrity or features of the safeguards system, and (E) a
15 four-wheel drive land vehicle used for transporting personnel and their hand-
16 carried equipment to the proximity of vital areas, and
17 (ii) An internal threat of an insider, including an employee (in any position), and
18 (iii) A four-wheel drive land vehicle bomb."

19 In announcing the revised DBT in April 2003, the NRC stated:²⁶

20 "The Commission believes that this DBT represents the largest reasonable threat
21 against which a regulated private security force should be expected to defend
22 under existing law."

23 Q. What is the DBT for an ISFSI?

24 A. The NRC's April 2003 announcement of a revised DBT did not mention ISFSIs. Thus, it
25 can be presumed that the previous DBT continues to apply to these facilities. For an ISFSI,
26 the previous DBT was the same as for a nuclear power plant except that it did not include
27 the use of a four-wheel-drive land vehicle, either for transport of personnel and equipment
28 or for use as a vehicle bomb. This was true whether the ISFSI was at a new site or a

NRC, 2002.

²⁵ 10 CFR 73.1, Purpose and Scope, from the NRC web site (www.nrc.gov).

²⁶ NRC Press Release No. 03-053, 29 April 2003.

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1 reactor site.²⁷ Thus, an ISFSI at a reactor site would be less protected than the reactor(s)
2 and spent-fuel pool(s) at that site. At a reactor site or a new site, an ISFSI would be
3 vulnerable to attack by a vehicle bomb.

4 Q. If the new DBT is not published, how do we know what it contains?

5 A. Its general characteristics can be inferred with reasonable confidence. Four major
6 considerations support such an inference. First, the new DBT must be consistent with 10
7 CFR 50.13. Second, the DBT will not exceed the capabilities of a "regulated private
8 security force". Third, there is a well-documented history over the past two decades,
9 showing vigorous resistance by the nuclear industry to measures that enhance site security,
10 and a reluctance by the NRC to contest that resistance.²⁸ Fourth, available information
11 shows no marked change in prevailing practices of site security.²⁹

12 Q. In your opinion, what is the general nature of the new DBT?

13 A. The new DBT remains focused on a ground assault by a comparatively small group of
14 lightly-armed attackers. The most destructive instrument included in the DBT is probably a
15 vehicle bomb. The new DBT probably does not allow for aerial or multi-modal attack by a
16 commando-type force. It probably does not allow for anti-tank missiles or lethal chemical
17 weapons. There is probably no provision for an attack using a commercial or general-
18 aviation aircraft, with or without a load of fuel or explosive. There is no provision for attack
19 using a nuclear weapon. The insider threat probably does not include carefully-planned,
20 sophisticated interventions by key employees. Also, the new DBT does not apply to
21 ISFSIs, so it can be assumed that ISFSIs continue to receive a lesser degree of protection

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²⁷ 10 CFR 73.1, Purpose and Scope, from the NRC web site (www.nrc.gov).

²⁸ Hirsch et al, 2003.

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1 than nuclear power plants. Finally, the scale of the presumed attack is such that backup for
2 the licensee's site-security force continues to be provided by local law-enforcement
3 agencies and the FBI, rather than the US military.

4 Q. You have discussed NRC requirements for defense of nuclear power plants and spent fuel,
5 including your understanding of the general nature of the new DBT. Please summarize your
6 conclusions regarding these requirements.

7 A. At present, the NRC requires only a light defense of nuclear power plants and spent fuel.
8 These requirements are inadequate in view of the nature of the threat and the need to
9 balance offensive and defensive means of protecting the nation.

10 **V. RISK OF ATTACK ON NUCLEAR POWER PLANTS AND SPENT FUEL**

11 Q. What are the factors that should be considered in securing a nuclear facility against the
12 threat of an attack?

13 A. Before deciding upon the level and type of defense for securing a nuclear power plant and
14 its spent fuel against the threat of an attack, a decision maker should assess the risk of a
15 successful attack. In this context, the concept of risk encompasses vulnerability to attack,
16 and the probability and consequences of attack.

17 One should assume that attackers are technically sophisticated and possess considerable
18 knowledge about individual nuclear facilities. For decades, engineering drawings,
19 photographs and technical analyses have been openly available for every civilian nuclear
20 facility in the US. This material is archived at many locations around the world. Thus, a
21 public discussion, in general terms, of potential modes and instruments of attack will not

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²⁹ POGO, 2002; Brian, 2003.

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1 assist attackers. Indeed, such a discussion is needed to ensure that appropriate defensive
2 actions are taken.³⁰

3 Q. Are nuclear power plants and spent-fuel-storage facilities designed to resist attack?

4 A. No. It is possible to design a nuclear power plant to resist attack, an example being the
5 proposed PIUS design.³¹ However, no US civilian nuclear facility has been designed to
6 resist attack. Any capacity that a facility has in this respect is a byproduct of designing to
7 account for other factors (earthquake, fire, equipment failure, human error, etc.).

8 Q. What are the points of vulnerability of a nuclear power plant?

9 A. The safe operation of a US commercial reactor and its associated spent-fuel pool(s)
10 depends upon the fuel in the reactor and the pool(s) being immersed in water. Moreover,
11 that water must be continually cooled to remove fission heat or radioactive decay heat
12 generated in the fuel. Various systems are used to ensure that water is available and is
13 cooled, and that other safety-related functions -- such as shutdown of the fission reaction
14 when needed -- are performed. Some of the relevant systems -- such as the electrical
15 switchyard -- are highly vulnerable to attack. Other systems are located inside reinforced-
16 concrete structures -- such as the reactor auxiliary building -- that provide some degree of
17 protection against attack. The reactor itself is inside a containment structure. At some
18 plants, but not all, the reactor containment is a concrete structure that is highly reinforced
19 and comparatively robust. Spent-fuel pools have thick concrete walls but are typically
20 covered by lightweight structures.

21 Q. Could attackers exploit points of vulnerability?

³⁰ For more detailed discussion of nuclear-facility vulnerability, see: Thompson, 2003; Thompson, 2002a.

³¹ Hannerz, 1983.

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1 A, Yes. Knowledgeable attackers could obtain a large release of radioactive material from a
2 nuclear power plant or its spent fuel by applying force in a targeted manner. To minimize
3 the need for brute force, knowledgeable attackers would seek to unleash sources of energy
4 (radioactive decay heat, stored thermal energy, energy of chemical reactions, etc.) that are
5 already present in the facility. In their planning, attackers could benefit from the large
6 published literature of probabilistic risk assessment (PRA) in the context of nuclear power
7 plant accidents.³² Attackers could hinder damage-control efforts by incapacitating plant
8 personnel through means that include a release of short-lived radioactive material from a
9 reactor core.

10 Q. Is the Diablo Canyon nuclear power plant unusual in its robustness or vulnerability?

11 A. The Diablo Canyon plant is a typical representative of the PWR nuclear power plants that
12 are common in the US. Its two reactor containments are comparatively thick-walled
13 concrete structures, and its two spent-fuel pools are partially sunk below grade level. These
14 design features provide some protection against attack. Nevertheless, the Diablo Canyon
15 plant has several points of vulnerability that will be evident to informed readers of PRA
16 literature.

17 Q. Do you have a particular area of concern regarding the Diablo Canyon nuclear plant?

18 A. Yes. The vulnerability of the spent-fuel pools deserves special consideration for two
19 reasons. First, each pool at the Diablo Canyon plant now contains an amount of long-lived
20 radioactive material that is substantially larger than the amount in a reactor core. Second,
21 the potential for a spent-fuel-pool fire exists because the Diablo Canyon pools have been

³² The state of the art for reactor PRAs is illustrated by: NRC, 1990.

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1 equipped with high-density racks. Loss of water from a pool could cause some or all of the
2 fuel in the pool to self-ignite and burn, releasing a large amount of radioactive material to the
3 atmosphere.³³
4 Because high-density racks have a closed structure, to suppress criticality, each fuel
5 assembly is surrounded by solid, neutron-absorbing panels, and there is little or no gap
6 between the panels of adjacent cells.³⁴ In the absence of water, this configuration allows
7 only one mode of circulation of air and steam around a fuel assembly -- vertically upward
8 within the confines of the neutron-absorbing panels. This mode of circulation provides less
9 effective transfer of radioactive decay heat than would occur in a low-density, open-frame
10 rack. Moreover, the upward flow of air or steam could be blocked by residual water or
11 debris. Thus, across a broad range of conditions, loss of water from a high-density pool
12 will cause the temperature of the fuel cladding to rise to the point where a self-sustaining,
13 exothermic oxidation reaction with air or steam begins. Other exothermic oxidation
14 reactions can also occur. For simplicity, the occurrence of one or more of the possible
15 reactions can be referred to as a pool fire.
16 Q. Do you believe that an attack on a civilian nuclear facility is possible?
17 A. Yes. I believe that a determined and sophisticated attack on a US nuclear power plant
18 and/or its spent fuel is a realistic possibility. There is a large amount of publicly available
19 information on the design of commercial nuclear power plant facilities, as well as the
20 amount, location, and method of storage of radioactive materials at each plant. Much is

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³³ The NRC has published a variety of technical documents that address spent-fuel-pool fires. The most recent of these documents is: Collins et al, 2000. For more recent analyses of spent-fuel-pool fires, see: Alvarez et al, 2003; Thompson, 2003; and Thompson, 2002a. The NRC Staff stated in March 2003 (NRC, 2003, page 10) that it has completed an "integral analysis of a spent fuel pool accident scenario", but this analysis has not been published.

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1 known about the nature of the security measures at each plant, including the fact that there
2 are no security measures designed specifically to address attacks from the air. Not only
3 does the nuclear-plant defense currently required by the NRC not address the full spectrum
4 of potential threats, but I believe that the US government's current policy of addressing
5 terrorism through an offense-dominated strategy is increasing the threat of terrorist attack.

6 Q. Would an effective attack require weapons not generally available to civilians?

7 A. Not necessarily. A nuclear power plant or an ISFSI could be attacked using one or more
8 of a variety of modes and instruments. Table V-1, below, shows a selection of potential
9 modes and instruments, summarizes their key characteristics, and describes the defenses
10 that are currently mounted against them.

11 One of the potential instruments of attack shown in Table V-1 is an explosive-laden smaller
12 aircraft. In this connection, it is noteworthy that the US General Accounting Office (GAO)
13 expressed concern, in September 2003 testimony to Congress, about the potential for
14 malicious use of general-aviation aircraft. The testimony stated:³⁵

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

25 A form of explosive that might be used in an attack on a nuclear power plant or an ISFSI is
26 a shaped charge. These have many civilian and military applications, and have been used

³⁴ Criticality is a situation in which a nuclear fission reaction becomes self-sustaining.

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1 for decades.³⁶ They are used, for example, as human-carried demolition charges or as
2 warheads for anti-tank missiles. In illustration of their availability, a quick search of the Web
3 identified a commercial supplier of military-surplus, shaped-charged warheads to licensed
4 civilian users. A surplus warhead with a diameter of 14 cm and length of 21 cm was
5 advertised as being capable of penetrating more than 65 cm of rolled homogeneous armor.
6 Much larger shaped charges are available. For example, the US government has
7 developed, and described in a published report, a shaped charge that can create a hole of
8 10 inches diameter to a depth of 20 feet in rock.³⁷

9 Q. Can the probability of a successful attack on a US nuclear power plant be estimated?

10 A. There is no statistical basis for such an estimate, because there has been no determined
11 attack on a US plant. It is prudent to assume that the probability of an attack on a US
12 nuclear power plant, with a substantial probability of success, is a realistic possibility. This
13 conclusion arises from the following qualitative considerations. First, the scale of the
14 planning and resources needed to mount an attack on a nuclear power plant, with a
15 substantial probability of success is a realistic possibility, would be comparable to the scale
16 of preparations for the attacks of September 11, 2001, and it is prudent to assume that
17 similar efforts will be mounted in the future. Second, senior officials in the US government
18 have repeatedly acknowledged that nuclear power plants are prime potential targets. Third,
19 groups like al-Qa'ida seek high-stakes objectives such as political control of Saudi Arabia
20 and its oil fields, and history tells us that confrontations over such objectives have frequently
21 involved high levels of violence. Fourth, the experience of the 20th century, during which

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³⁵ Dillingham, 2003, page 14.

³⁶ Walters, 2003.

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1 the US homeland suffered only limited attacks, will not necessarily be repeated during the
2 21st century.

3 Q. What is your assessment of the potential release of cesium-137 from the Diablo Canyon
4 plant in the event of an attack?

5 A. As discussed above, each of the two spent-fuel pools at the Diablo Canyon plant will
6 contain, from 2006 forward, about 56 million Curies (630 kilograms) of cesium-137. Each
7 of the two reactor cores contains about 6 million Curies (67 kilograms) of cesium-137. A
8 typical dry-storage cask at the planned ISFSI will contain about 1.3 million Curies (14
9 kilograms) of cesium-137. During a spent-fuel-pool fire, the fractional release of cesium-
10 137 to the atmosphere could range from 10 to 100 percent.³⁷ A similar range of release
11 fractions can be assumed for attack-induced atmospheric releases from reactor cores or dry
12 casks. An attack on the Diablo Canyon plant could lead to an atmospheric release of
13 radioactive materials from one or both of the reactors, and/or one or both of the spent-fuel
14 pools, and/or the planned ISFSI. Thus, the atmospheric release of cesium-137 following an
15 attack on the Diablo Canyon plant could exceed 100 million Curies. The actual magnitude
16 of the release would depend on the attack scenario.

17 Q. Are there studies on the consequences of such a release of cesium-137?

18 A. Yes. For example, some of the consequences of a large, atmospheric release of cesium-
19 137 have been estimated in a recent paper by three of my colleagues.³⁹ They assumed a
20 release of 3.5 or 35 million Curies of cesium-137 at each of five nuclear-power-plant sites
21 (not including the Diablo Canyon site), and estimated the offsite economic damage. For a

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³⁷ This device has a diameter of 28 inches and a length of 29 inches, and weighs 900 pounds.

³⁸ Alvarez et al, 2003.

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1 release of 35 million Curies, the 5-site average economic damage was found to be about
2 \$400 billion. The costs considered were: (i) compensation for loss of contaminated real
3 estate and other property; (ii) relocation costs; (iii) decontamination costs; and (iv) costs of
4 disposing of wastes generated during decontamination. A simple analytic process was used,
5 and the authors relied heavily on a 1996 study done for Sandia National Laboratories. That
6 study identified factors that could bias its cost estimates downward, including: (i) its neglect
7 of administrative and support costs that could double the cost estimates; (ii) its neglect of
8 litigation costs; and (iii) its neglect of impacts on downtown business and commercial
9 districts, heavy-industrial areas, and high-rise apartment buildings. Consideration of these
10 factors would increase the \$400 billion estimate made by my colleagues.

11 My colleagues' paper estimated that, for a release of 35 million Curies of cesium-137, the
12 5-site average of additional cancer deaths would be about 6,000 deaths. These deaths
13 were valued at \$4 million each, yielding a cost of \$24 billion. If the release also included
14 short-lived radioactive isotopes, as would occur if a reactor core were involved in the
15 release incident, there could be additional cancer deaths.

16 My colleagues considered a set of direct costs arising from contamination of the
17 environment with cesium-137. There would be many additional, indirect costs of a
18 successful attack on a US nuclear power plant, including the following five examples. First,
19 the attack would probably lead to temporary or permanent shutdown of other nuclear plants
20 across the nation, leading to additional costs for electricity supply. Second, domestic and
21 foreign markets for US agricultural products and other goods would be depressed by
22 customers' fear of radioactive contamination. Third, the attack would be perceived

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³⁹ Beyea et al, 2004.

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1 internationally as a major blow to the US, thereby affecting capital flows, exchange rates,
2 and market valuations. Fourth, the attack would probably lead to a reduction of civil
3 liberties, potentially including a period of martial law, with long-term negative effects on the
4 economy. Fifth, there would probably be large additional US expenditures on homeland
5 security and, potentially, on offensive military operations.

6 Q. How is the above analysis relevant to this proceeding regarding the Diablo Canyon plant?

7 A. Analysis could be performed to estimate the direct costs of an atmospheric release of
8 cesium-137 from the Diablo Canyon plant. Also, the accompanying indirect costs could be
9 analyzed. In the absence of such analyses, it is prudent to assume that the direct and
10 indirect economic consequences of a successful attack on the Diablo Canyon nuclear power
11 plant would be not less than \$1,000 billion.

12 ///

13 ///

14 ///

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**Table V-1
 Potential Modes and Instruments of Attack on a Nuclear Power Plant⁴⁰**

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

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VI. TRENDS TOWARD ENHANCED DEFENSE OF NUCLEAR POWER PLANTS AND SPENT FUEL

Q. What is the likelihood that there will be more stringent requirements for defense of nuclear power plants in the United States?

A. As stated in Section IV, above, the NRC has increased licensees' obligations to defend nuclear facilities in the aftermath of terrorist attacks. One important step was the adoption in 1994 of a rule requiring licensees to defend nuclear power plants against vehicle bombs. Other, similar steps have been taken since September 11, 2001. Present trends suggest that the NRC and/or other arms of the federal government will, over the coming years,

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1 require and/or provide further enhancement of the defense of nuclear power plants and
2 spent fuel. These trends are evident in the general area of homeland security, and in the
3 specific area of nuclear-facility security.

4 Q. Please describe the trends in homeland security.

5 A. An important indicator of overall homeland-security trends is the level of total expenditure in
6 this area. Reliable data on total expenditure are lacking, so estimates must be made. One
7 estimate of total US homeland-security expenditure – by federal, state, local and private
8 entities – shows annual expenditure growing from \$5 billion in 2000 to \$85 billion in 2004,
9 with anticipated growth to \$130 billion, or perhaps as high as \$210 billion, in 2010.⁴¹

10 A recent incident illustrates the increased attention now given to homeland-security threats.
11 On June 9, 2004, an aircraft carrying the governor of Kentucky approached Washington,
12 DC, without a functioning transponder. Detection of this approach triggered a rapid
13 evacuation of the Capitol building and surrounding office buildings.

14 Two patrolling F-15 fighter planes were directed to intercept the aircraft, but did not reach
15 it in time to shoot it down if it had proceeded toward the Capitol. In discussing this incident,
16 officials noted that the federal government provides a layered defense of Washington that
17 includes ground-based anti-aircraft missiles.⁴²

18 An aspect of the war in Iraq illustrates the challenge of defending energy infrastructure, and
19 holds lessons for homeland security. Offshore terminals are part of Iraq's infrastructure for
20 the export of oil. At these terminals, oil is transferred from underwater pipelines to tankers.

21 Two of these terminals were attacked, but not extensively damaged, by boat-bomb suicide

⁴⁰ Adapted from Table 1 of: Thompson, 2003.

⁴¹ Barami, 2004.

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1 | missions on April 24, 2004. Currently, the terminals are defended by US, UK and
2 | Australian warships, and by gun emplacements on the terminals. Radar and optical imagery
3 | are used to detect approaching boats. An exclusion zone of 2,000 meters is maintained.
4 | Gunners are authorized to fire at boats approaching within 500 yards. During the April
5 | 2004 attacks, gunfire from Iraqi security forces caused two of the three attacking boats to
6 | explode prematurely.⁴³

7 | Q. Please describe the current trends in nuclear-plant security.

8 | A. Increasingly, citizens and public officials across the US have called upon the federal
9 | government to re-think its approach to the defense of US nuclear power plants and spent
10 | fuel. For example, in October 2002 the Attorneys-General of 27 states sent a letter to the
11 | majority and minority leaders of the US Senate and House of Representatives.⁴⁴ The letter
12 | called for "passage of legislation this year to protect our states and communities from
13 | terrorist attacks against nuclear power plants and other sensitive nuclear facilities". Special
14 | attention was drawn to the vulnerability of spent-fuel pools. Congress has not yet acted on
15 | this letter. As another example, the Attorneys-General of California, Massachusetts, Utah
16 | and Washington, as well as San Luis Obispo County and Mothers for Peace, have joined in
17 | litigation seeking a full evidentiary hearing to examine the threat posed by potential acts of
18 | malice or insanity at the planned ISFSI at Diablo Canyon.

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⁴² Solomon, 2004.

⁴³ Glanz, 2004.

⁴⁴ Letter from the Attorneys-General of Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Hawaii, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Montana, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Vermont, West Virginia, Washington and Wisconsin to the Senate Majority and Minority Leaders, the Speaker of the House and the House Minority Leader, 8 October 2002.

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1 Q. In addition, publications by other authors and me helped to influence Congress to request
2 from the National Academy of Sciences (NAS) an independent, classified study on the
3 security of spent-fuel storage. Congress was motivated to take this action by concern that
4 the NRC was not properly considering the threat to spent fuel.⁴⁵ The study began in
5 January 2004, and it is said that a classified report was provided to Congress in late June or
6 early July 2004. Congress has requested the NRC to "take recommendations of the final
7 NAS report seriously and to take actions to address these recommendations at the earliest
8 possible date".⁴⁶ There is speculation that NAS recommendations for enhancing the
9 security of spent-fuel pools include: (i) distributing fuel in a pool so that hotter and cooler
10 assemblies are separated; and (ii) installing spray equipment to cool spent fuel in the event
11 that water is lost from a pool.

12 Another illustration of the trend toward enhanced defense of nuclear facilities is the pressure
13 upon the US Department of Energy (DOE) to improve the security of Category I special
14 nuclear material – plutonium and highly-enriched uranium. At a Congressional hearing in
15 April 2004, a GAO witness and the chair of the committee holding the hearing pointed out
16 that DOE's present DBT -- promulgated in May 2003 -- for Category I material was
17 developed too slowly, will be implemented over too long a period, and is inadequate to
18 meet the threat. A Postulated Threat to the security of Category I material has been
19 articulated by the intelligence community.⁴⁷ For sites that handle nuclear weapons, DOE's
20 present DBT represents the lower range of the threat identified in the Postulated Threat.

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⁴⁵ Inside NRC staff, 2003.

⁴⁶ Weil, 2004.

⁴⁷ A Postulated Threat is a hypothetical threat that can be used for planning purposes and is, in effect, a suggested DBT.

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1 For other Category I sites, the present DBT is significantly smaller than the Postulated
2 Threat.⁴⁸ It is likely that DOE will come under increasing pressure to rectify these
3 deficiencies.

4 As another example, the final version of the Coast Guard Authorization Act, which passed
5 the US Senate in late July 2004, includes a provision that requires the Coast Guard to
6 assess the vulnerability of US nuclear power plants to attack from adjacent bodies of water.
7 The Coast Guard must complete this assessment within one year and report the findings to
8 Congress.

9 Q. How has the nuclear industry reacted to the trends you describe?

10 A. Within the nuclear-power industry, there is growing recognition that the industry will be
11 obliged to respond to public demands for an enhanced defense of nuclear power plants and
12 spent fuel. In illustration, a group of owners of nuclear power plants in Germany has
13 contracted with the armaments company Rheinmetall to install smoke-generating machines
14 at their plants, to hinder the approach of hostile aircraft. A system of this kind has been
15 tested successfully. It is said that full deployment could occur within one year.⁴⁹ As
16 another example, in April 2004 the Holtec company asked the NRC to provide expedited
17 generic approval of partial-underground placement of casks for dry storage of spent fuel.
18 This system would employ the Holtec HI-STORM 100 cask, the type of cask that is to be
19 used at the planned ISFSI at the Diablo Canyon plant. The top of the cask would project
20 about 2 feet above ground. Holtec has described this system as offering "the next level of

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⁴⁸ Schwartz, 2004.

⁴⁹ Reuters, 2004.

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1 protection against terrorist attacks".⁵⁰ There is no indication that PG&E intends to employ
2 this system at the Diablo Canyon plant.

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3 **VII.A POTENTIAL PLAN FOR ENHANCED DEFENSE OF THE DIABLO**
4 **CANYON PLANT**

5 Q. What are the implications for the Diablo Canyon plant of the trends that you have described
6 above?

7 A. It is reasonable and prudent to assume that the Diablo Canyon nuclear power plant and its
8 spent fuel will receive an enhanced defense during the coming years. In order to estimate
9 the additional costs to PG&E that could arise from the provision of an enhanced defense, it
10 is necessary to articulate a plan for enhanced defense. Here, I set forth a potential plan that
11 could be required by the NRC and/or other arms of the federal government.

12 Q. What are the features of the potential plan?

13 A. I assume that the plan would employ the principles of defense in depth, and would
14 encompass four categories of defensive measures: (i) site security; (ii) facility robustness; (iii)
15 damage control; and (iv) emergency response planning.

16 Q. Please describe the additional site-security measures.

17 A. Site-security measures are those that reduce the potential for implementation of destructive
18 acts of malice or insanity at a nuclear site. Two types of measures -- "generic" measures
19 and "site-specific" measures -- fall into this category. Generic measures are implemented at
20 offsite locations, and protect multiple sites. The implementing agencies might have no direct
21 connection with a particular site. Airline or airport security measures are examples of
22 generic measures. Site-specific measures would be implemented at or near a nuclear site.

⁵⁰ Conley, 2004.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 Implementing agencies would include the licensee, the NRC and other entities such as the
2 National Guard. The physical protection measures now required by the NRC, as discussed
3 in Section IV, above, are examples of site-specific measures.

4 Additional, generic, site-security measures are not discussed here. The lack of such a
5 discussion does not imply that present measures of this kind are adequate or optimal. The
6 focus here is on site-specific measures, because these measures are directly relevant to the
7 economics of the Diablo Canyon plant. I believe that the following set of additional site-
8 security measures is representative of what would be required for the Diablo Canyon site
9 under an enhanced-protection plan:

10 (i) Establishment of a mandatory aircraft-exclusion boundary around the site.

11 (ii) Deployment of an aircraft-detection system that triggers security alerts as the exclusion
12 boundary is approached and crossed.

13 I assume that the Sentinel system – a portable, phased-array radar system -- would be used
14 to detect approaching aircraft. Two units of Sentinel should suffice. The units would be
15 owned and operated by the military, probably the National Guard, but PG&E would bear
16 the costs of their deployment and operation. The objective of deploying Sentinel would be
17 to provide continuous detection, tracking and identification of aircraft near to and within the
18 mandatory aircraft-exclusion boundary. This information would be conveyed to the Diablo
19 Canyon plant by secure, redundant communication links. As an approaching aircraft
20 reached specified distances from the plant, with specified vectors, Sentinel would trigger a
21 succession of security alerts.

22 (iii) Deployment of an automated system to destroy aircraft at short range if they are closing
23 on the plant.

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Comment Set CC6, cont.

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1 I assume that the Phalanx system – an automated gun – would be used for this purpose.
2 Originally designed to intercept anti-ship missiles, Phalanx has been modified to intercept a
3 range of fast- and slow-moving targets including missiles, fixed-wing and rotary-wing
4 aircraft, and sea-surface targets. At the Diablo Canyon plant, two Phalanx units could
5 provide reliable coverage. Again, the units would be owned and operated by the military,
6 probably the National Guard, but PG&E would bear the costs of their deployment and
7 operation.

8 (iv) Expansion of the DBT, beyond that now specified by the NRC, to include additional
9 intruders, heavy weapons, aircraft attack, lethal chemical weapons and more than one
10 vehicle bomb.

11 (v) Provision at the planned ISFSI on the site of protection equivalent to that provided for
12 the nuclear generating units.

13 The additional defensive measures in (iv) and (v), above, would require an expanded
14 defensive perimeter to accommodate the planned ISFSI, might require strengthening of
15 vehicle barriers to resist more than one vehicle bomb, and would require a larger and more
16 capable guard force. A model for the upgraded guard force could be the force that
17 protects DOE's most sensitive sites. GAO has described the protection of these sites as
18 follows:⁵¹

19 "While specific measures vary from site to site, all protective systems at DOE's
20 most sensitive sites employ a defense-in-depth concept that includes sensors,
21 physical barriers, hardened facilities and vaults, and heavily armed paramilitary
22 protective forces equipped with such items as automatic weapons, night vision
23 equipment, body armor, and chemical protective gear."

⁵¹ Nazzaro, 2004, page 4.

Comment Set CC6, cont.

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1 This set of measures reflects the threat of attack from the air, and the present lack of
2 defense against air attack. Measures to enhance defense against ground or sea attack are
3 also included. The measures I describe would seek to accommodate separate or combined
4 attacks from air, land or sea, together with actions by insiders.

5 Q. Please describe the second category of additional defensive measures, namely "facility-
6 robustness measures".

7 A. Facility-robustness measures are defensive measures that improve the ability of a nuclear
8 facility to experience destructive acts of malice or insanity without a significant release of
9 radioactive material to the environment. An integrated set of additional facility-robustness
10 measures that I believe could be required for the Diablo Canyon plant is as follows:

11 (i) Automated shutdown of the reactors upon initiation of a specified alert status at the
12 plant, with provision for completion of the automated shutdown sequence if a control
13 room is disabled.

14 Automated shutdown of the reactors would serve two purposes. First, it could increase the
15 time interval between reactor shutdown and onset of damage to safety systems, thereby
16 reducing the level of decay heat that would have to be removed from the reactor by
17 degraded safety systems. Second, it could increase the probability that a reactor would be
18 brought to a safe-shutdown condition if the control room were disabled. The second of
19 these purposes is probably the most significant from a risk-reduction perspective. To
20 achieve the second purpose, the automated-shutdown system would have to be located
21 apart from the control room, with redundant communication links to the control room, plant
22 safety systems, and offsite facilities. The automated-shutdown system would be designed to

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Comment Set CC6, cont.

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1 detect a loss of capability in the control room, and would thereupon assume command of
2 the shutdown process.

3 (ii) Permanent deployment of diesel-driven pumps and pre-engineered piping to be
4 available to provide emergency water supply to the reactors and the spent-fuel pools.

5 This capability would provide an additional supply of water, under emergency conditions, to
6 cool the reactor cores and spent fuel in the pools. It would support the additional damage-
7 control measures that are discussed below. If other sources of water were not available,
8 the additional pumps would draw water from the ocean. As needed during an emergency,
9 this new system could be manually connected to existing cooling systems such as the
10 component-cooling system, the feedwater system, the safety-injection system, the
11 containment-cooling system, and the fire-protection system. Also, the new system could be
12 used to refill a drained spent-fuel pool or to spray water on exposed fuel. The existing
13 cooling systems at the Diablo Canyon plant are designed to contain radioactive material and
14 preserve the integrity of the plant in the event of an accident. By contrast, the new system
15 would have one overriding objective – to prevent or limit the release of radioactive material
16 to the atmosphere. In some attack scenarios, meeting that objective could involve releases
17 of radioactive material to surface water, ground water or the ocean. Use of ocean water for
18 emergency cooling could render the plant unfit for further operation if the plant survived the
19 incident.

20 (iii) Re-equipment of the spent-fuel pools with low-density racks, excess fuel being stored in
21 an onsite ISFSI.

22 The following discussion illustrates how this might be done. First, each of the two Diablo
23 Canyon reactors would operate on a 20-month refueling cycle and discharge 90 spent-fuel

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Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 assemblies per refueling. Second, each pool would contain 1,100 fuel assemblies at the
2 point when operations begin to re-equip the pools with low-density racks. Third, each pool
3 would, after re-equipment with low-density racks, have a capacity of 470 fuel assemblies.⁵²
4 This capacity would support a full-core offload of 193 fuel assemblies plus three refueling
5 discharges of 90 assemblies per discharge, thereby allowing fuel to age over three refueling
6 cycles -- 60 months, or 5 years -- before it is transferred to an onsite ISFSI. Thus, while
7 the core is in the reactor, each pool would contain up to 270 fuel assemblies. Fourth,
8 reduction of the spent-fuel inventory in each pool, from 1,100 assemblies to 270
9 assemblies, would occur over a period of 2 years. It follows that the onsite ISFSI would
10 receive 830 fuel assemblies per year during an initial 2-year period, and an average of 108
11 fuel assemblies per year thereafter.

12 (iv) Construction of the ISFSI to employ hardened, dispersed, dry storage of spent fuel.

13 There is, at present, no indication that PG&E intends to change the design of the planned
14 ISFSI at the Diablo Canyon plant, so as to employ hardened, dispersed, dry storage of
15 spent fuel. As I have noted above, the Holtec company has asked the NRC to provide
16 expedited generic approval of partial-underground placement of HI-STORM 100 dry-
17 storage casks, the type of cask that is to be used at Diablo Canyon. This arrangement
18 might satisfy requirements for hardened, dispersed, dry storage, although concerns have
19 been expressed about the quality and durability of Holtec casks. I have written at length

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⁵² Each Diablo Canyon spent-fuel pool has a floor area, excluding the cask pit, of 1,282 square feet (see: PG&E, 1985, Figures 2.1a and 2.1b). Racks with a capacity of 470 fuel assemblies would occupy, on average, 2.73 square feet per fuel assembly. This density would allow a center-to-center spacing of fuel assemblies of up to 20 inches, which would allow the use of open-frame racks.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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- 1 about the need for hardened, dispersed, dry storage of spent fuel, and the options for
2 providing such storage.⁵³
- 3 Q. Please describe the third category of additional defensive measures, namely "damage-
4 control measures".
- 5 A. Damage-control measures are those that reduce the potential for a release of radioactive
6 material following damage to a facility by destructive acts of malice or insanity. Measures of
7 this kind could be ad hoc or pre-engineered. An example of a damage-control measure is a
8 set of arrangements for patching and restoring water to a spent-fuel pool that has been
9 breached. It appears that the NRC has required licensees of nuclear power plants to
10 undertake some planning for damage control following explosions or fires.⁵⁴ The following
11 are additional measures that could be taken at Diablo Canyon:
- 12 (i) establishment of a pre-planned damage-control capability at the site, using onsite
13 personnel and equipment for first response and offsite resources for backup;
- 14 (ii) periodic exercises of damage-control capability;
- 15 (iii) establishment of a set of damage-control objectives -- to include patching and restoring
16 water to a breached spent-fuel pool, fire suppression at the onsite ISFSI, and provision
17 of cooling to a reactor whose safety systems and/or control room are disabled -- with
18 accompanying detailed plans and stockpiling of needed supplies; and
- 19 (iv) provision of equipment and training to allow damage control to proceed on a
20 radioactively-contaminated site.

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⁵³ Thompson, 2003.

⁵⁴ Meserve, 2002b.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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- 1 Q. Please describe the fourth category of additional defensive measures, namely "emergency-
2 response measures".
- 3 A. Emergency-response measures are those that reduce the potential for exposure of offsite
4 populations to radiation, following a release of radioactive material from a nuclear facility.
5 Measures in this category could accommodate releases attributable to acts of malice or
6 insanity, or "accidental" releases arising from human error, equipment failure or natural
7 forces (e.g., earthquake). However, there are two major ways in which malice- or insanity-
8 induced releases might differ from accidental releases. First, a malice- or insanity-induced
9 release might be larger and begin earlier than an accidental release.⁵⁵ Second, a malice- or
10 insanity-induced release might be accompanied by deliberate degradation of emergency
11 response capabilities (e.g., the attacking group might block an evacuation route).
12 Accommodating these differences could require additional measures of emergency
13 response.
- 14 A team based at Clark University in Massachusetts has developed a model emergency
15 response plan that could be implemented at the Diablo Canyon plant to significantly enhance
16 emergency-response capability.⁵⁶ This model plan was specifically designed to
17 accommodate radioactive releases from spent-fuel-storage facilities, as well as from
18 reactors. That provision, and other features of the plan, would provide a capability to
19 accommodate both accidental releases and malice- or insanity-induced releases. Major
20 features of the model plan include:⁵⁷

⁵⁵ Present plans for emergency response do not account for the potential for a large release of radioactive material from spent fuel, as would occur during a pool fire. The underlying assumption is that a release of this kind is very unlikely. That assumption cannot be sustained in the present threat environment.

⁵⁶ Golding et al, 1992.

⁵⁷ Golding et al, 1992, pp 8-13.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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- 1 (i) structured objectives;
- 2 (ii) improved flexibility and resilience, with a richer flow of information;
- 3 (iii) precautionary initiation of response, with State authorities having an independent
- 4 capability to identify conditions calling for a precautionary response⁵⁸;
- 5 (iv) criteria for long-term protective actions;
- 6 (v) three planning zones, with the outer zone extending to any distance necessary⁵⁹;
- 7 (vi) improved structure for accident classification;
- 8 (vii) increased State capabilities and power;
- 9 (viii) enhanced role for local governments;
- 10 (ix) improved capabilities for radiation monitoring, plume tracking and dose projection;
- 11 (x) improved medical response;
- 12 (xi) enhanced capability for information exchange;
- 13 (xii) more emphasis on drills, exercises and training;
- 14 (xiii) improved public education and involvement; and
- 15 ///
- 16 (xiv) requirement that emergency preparedness be regarded as a safety system
- 17 equivalent to in-plant systems.

18 **VIII. COSTS OF IMPLEMENTING THE ENHANCED-DEFENSE PLAN FOR THE**

19 **DIABLO CANYON PLANT**

20 Q. How have you estimated the additional costs to PG&E that would arise from introduction of

21 the enhanced-defense measures that you have described above?

⁵⁸ A security alert could be a condition calling for a precautionary response.

⁵⁹ In the original Clark University plan, the inner and intermediate zones would have radii of 5 and 25 miles, respectively. As an example of the planning measures in each zone, potassium iodide would be pre-

Comment Set CC6, cont.

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1 A. As a first step, I have reviewed data on the overall operating and maintenance (O&M)
2 expenses and capital expenses at the Diablo Canyon plant. These data provide a baseline
3 for considering the costs that arise from defending the plant. Second, I have reviewed
4 PG&E historical data and projections on the portions of the O&M expenses and capital
5 expenses for the Diablo Canyon plant that are attributable to measures for defending the
6 plant. As a third and final step, I have estimated the additional costs of providing the
7 enhanced-defense measures that are set forth in Section VII, above.

8 Q. What are the overall O&M expenses for the Diablo Canyon plant with its present level of
9 defense?

10 A. Table VIII-1 below, which is taken from PG&E's 2003 General Rate Case filing, shows
11 the overall O&M and nuclear fuel expenses for the Diablo Canyon plant, as projected by
12 PG&E in 2003 for the period 2002-2005. I recognize that PG&E has updated these
13 projections in the context of these proceedings. However, the projections shown in Table
14 VIII-1 remain useful for two reasons. First, this table shows the number of personnel for
15 each expense category. Second, this table shows "loss prevention" as an expense category.
16 That category covers site security, industrial safety and health, emergency preparedness,
17 and fire protection. There is no equivalent category in the PG&E projections that have been
18 submitted in these proceedings.⁶⁰ Those projections show average O&M expenses of
19 \$280 million per year for the period 2002-2005, a value 9 percent higher than the \$257
20 million shown in Table VIII-1.

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distributed within the 25-mile zone and made generally accessible nationwide. This zonal arrangement would require adaptation to the specific circumstances of the Diablo Canyon site.

⁶⁰ PG&E, Chapter 5A, Detailed Testimony on Operation and Maintenance Expenses and Capital Expenditures, revised 05/27/04, Table 5A-1.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 Q. What are the overall capital expenses for the Diablo Canyon plant with its present level of
2 defense?

3 A. PG&E states that capital expenses for the period 2000-2002 averaged \$14.3 million per
4 year. PG&E projects, assuming that the plant's steam generators are replaced, that capital
5 expenses will average \$141 million per year for the period 2003-2011 and \$42.2 million
6 per year for the period 2012-2024.⁶¹

7 Q. What portion of the overall O&M expenses for the Diablo Canyon plant is attributable to
8 measures for defending the plant at the present level of defense?

9 A. Some relevant historical data have become available in data responses from PG&E in these
10 proceedings.⁶² These data show that O&M costs for site security at the Diablo Canyon
11 plant averaged \$13.3 million annually over the period 1997-2003, with a maximum annual
12 value of \$17.8 million in 2003, while O&M costs for emergency-response planning
13 averaged \$1.3 million annually over the period 1998-2003.

14 PG&E has estimated the additional O&M costs for site security that will arise from security
15 enhancements attributable to the attacks of September 11, 2001. The annual value of these
16 additional costs is \$2 million in 2003, \$5 million in 2004, \$4 million in 2005, and \$5 million
17 during the period 2006-2010.⁶³

18 Q. What portion of the overall capital expenses for the Diablo Canyon plant is attributable to
19 measures for defending the plant at the present level of defense?

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⁶¹ PG&E, Chapter 5A, Detailed Testimony on Operations and Maintenance and Capital Expenditures, Workpapers – Application, pages 5A-17 and 5A-18.

⁶² PG&E Data Responses MFP002-12 and 002-13, June 30, 2004.

⁶³ PG&E, Chapter 5A, Detailed Testimony on Operation and Maintenance Expenses and Capital Expenditures, revised 05/27/04, Table 5A-14.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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- 1 A. A data response from PG&E in these proceedings shows that capital expenses for site
2 security over the period 1997-2003 averaged \$1.6 million annually, while capital expenses
3 for emergency-response planning averaged \$0.2 million annually over the same period.⁶⁴
4 PG&E has estimated the additional capital costs for site security that will arise from
5 compliance with NRC orders. The annual value of these additional costs is \$1 million in
6 2003, \$5 million in 2004, and zero during the period 2005-2006.⁶⁵
- 7 Q. What are your estimates of the additional costs to PG&E that would arise from deployment
8 of the Sentinel and Phalanx systems?
- 9 A. For Sentinel, I estimate a capital expense of \$15 million over an initial 2-year period in
10 providing infrastructure support and an annual O&M expense of \$8.5 million. Based on a
11 projected sale, I estimate the cost of the Sentinel system to be approximately \$3.7 million
12 per unit.⁶⁶ I assume here that: (i) the Sentinel units at Diablo Canyon would be owned and
13 operated by the US military, but PG&E would bear the costs of their deployment and
14 operation; (ii) the capital cost to the military of deploying two Sentinel units at Diablo
15 Canyon would be \$10 million; (iii) the capital cost would be recovered from PG&E over 4
16 years without interest; and (iv) continuous operation would require a 30-FTE crew costing,
17 with overheads and supplies, \$0.2 million per annum per person.⁶⁷
- 18 For Phalanx, I estimate a capital expense of \$20 million over an initial 2-year period in
19 providing infrastructure support and an estimated annual O&M expense of \$11 million. The

⁶⁴ PG&E Data Response, MFP002-14.

⁶⁵ PG&E, Chapter 5A, Detailed Testimony on Operation and Maintenance Expenses and Capital Expenditures, revised 05/27/04, Table 5A-25.

⁶⁶ DSCA, 2002.

⁶⁷ From Table VIII-1, it will be noted that the O&M cost per FTE staff member at Diablo Canyon is \$194,000.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 same O&M assumptions discussed above for Sentinel are applied to the Phalanx system,
2 except that the capital cost of two Phalanx units is assumed to be \$20 million.⁶⁸

3 Q. What is your estimate of the additional costs to PG&E of meeting an expanded DBT and
4 providing the planned ISFSI with the same level of protection as is provided for the nuclear
5 generating units?

6 A. I estimate an additional annual O&M expense of \$15 million to meet these requirements,
7 assuming that PG&E would need to increase the size of its security workforce by
8 approximately 75 FTE, at a cost, with overheads and supplies, of \$0.2 million per annum
9 per person. In addition, I assume an additional annual capital cost of \$5 million.

10 Q. What are your estimates of the additional costs of providing an automated shutdown system
11 and a new system to supply cooling water under emergency conditions?

12 A. In both cases I estimate an additional capital expense of \$75 million over an initial 2-year
13 period.⁶⁹ Also, I assume that R&D costs for these new systems would be borne by the
14 NRC or another arm of the federal government, potentially with cost recovery from all
15 licensees of US nuclear power plants.

16 Q. What is your estimate of the additional costs of reducing inventory in the spent-fuel pools
17 and providing hardened, dispersed, dry storage of the excess fuel in an onsite ISFSI?

18 A. I estimate an additional capital expense of \$91 million per year for an initial 2-year period
19 and \$6 million per year thereafter. In Section VII, above, I describe a reduction of the
20 spent-fuel inventory in each Diablo Canyon pool from 1,100 assemblies to 270 assemblies
21 over a period of 2 years. Thus, the onsite ISFSI would receive 830 fuel assemblies per

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⁶⁸ An amateur website (Doehring, 2004) gives a unit cost of \$5.6 million for Phalanx.

⁶⁹ This estimate reflects a range of \$50-60 million.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 year during an initial 2-year period, and an average of 108 fuel assemblies per year
2 thereafter. Note that the onsite ISFSI would receive an average of 108 fuel assemblies per
3 year in the absence of a plan for providing an enhanced defense of the Diablo Canyon plant.
4 Additional costs would arise in three respects. First, during an initial 2-year period, the
5 onsite ISFSI would receive an additional $830 - 108 = 722$ fuel assemblies per year.
6 Second, additional costs would arise in providing hardened, dispersed storage at the onsite
7 ISFSI. Third, costs would arise in replacing the existing racks in the Diablo Canyon pools
8 with low-density, open-frame racks.
9 The capital cost of placing spent fuel in dry casks at ISFSIs at US nuclear power plants
10 ranges from \$90 to \$210 per kg of uranium.⁷⁰ Here, I assume that the capital cost for the
11 currently-planned ISFSI at Diablo Canyon would be \$120 per kg of uranium, while the
12 capital cost for a hardened, dispersed ISFSI would be \$240 per kg
13 of uranium. A fresh Diablo Canyon fuel assembly contains 460 kg of uranium. Thus,
14 placing 722 fuel assemblies in a hardened, dispersed ISFSI at Diablo Canyon would involve
15 a capital expense of \$80 million. The incremental capital expense of placing 108 fuel
16 assemblies in a hardened, dispersed ISFSI at Diablo Canyon, instead of in the currently-
17 planned ISFSI, would be \$6 million. I assume that replacement of the high-density racks in
18 the Diablo Canyon spent-fuel pools with low-density racks would involve a capital expense
19 of \$10 million over a 2-year period.
20 Q. What are your estimates of the additional costs of providing enhanced capabilities for onsite
21 damage control and offsite emergency response?

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⁷⁰ Alvarez et al, 2003, page 31.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1 A. In both cases I estimate an additional annual O&M expense of \$10 million and an additional
2 annual capital cost of \$2 million. Providing the enhanced capability for onsite damage
3 control would require an increase in the size of the Diablo Canyon workforce. I assume a
4 50-FTE increase. At a cost, with overheads and supplies, of \$0.2 million per annum per
5 person, this step would increase PG&E's annual O&M
6 expense by \$10 million. I assume that the same increase in personnel and annual O&M
7 expense would be required to provide the enhanced capability for offsite emergency
8 response. In this instance, however, some of the additional staff would work for state and
9 local governments.

10 Q. What is the overall additional cost of providing the enhanced defense of the Diablo Canyon
11 plant?

12 A. Table VIII-2 summarizes the cost estimates developed above. Note that these costs are
13 additional to the O&M expenses and capital expenses that PG&E is currently incurring.

14 My cost estimates are preliminary. More accurate cost estimates would require: (i)
15 articulation of the enhanced-defense measures in more detail; (ii) comparison of the
16 enhanced-defense measures with similar projects that have been recently implemented at
17 US nuclear power plants or other security-intensive facilities; and (iii) use of the
18 comparisons developed in (ii) to extrapolate from actual costs of recently-implemented
19 projects.

20 ///

21
22

**Table VII-1
Diablo Canyon O&M and Nuclear Fuel Expenses:**

CC6-111

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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1

Annual Average for 2002-2005 as Projected by PG&E in 2003⁷¹

Expense Category	2002-2005 Annual Average Expense (\$ million)	Approximate Number of Personnel
Manage production	37.2	284
Manage DCPD plant assets	112	499
People performance	19.5	67
Manage business and information management	23.8	100
Manage supply chain	5.59	51
Manage engineering assets and maintain license and strategic projects	36.7	156
Loss prevention	22.5	168
Subtotal	257	1,325
Nuclear fuel	86.9	
Total	343.9	

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Table VIII-2

8

Estimated Additional Costs of Potential Measures to Provide Enhanced Defense of the
 Diablo Canyon Nuclear Power Plant and its Spent Fuel

9

Defensive Measure	Capital Expense (\$ million)	Annual O&M Expense (\$ million)
Sentinel (2 units)	7.5/yr for 2 yrs	8.5
Phalanx (2 units)	10/yr for 2 yrs	11

⁷¹ Notes:

- (i) Expenses are in mixed, unadjusted, current-year dollars.
- (ii) O&M expenses are actual 2001 values adjusted to account for projected changes.
- (iii) Personnel numbers "are approximate since employees often work in more than one process and split their time accordingly".
- (iv) A 1987 study (EIA, 1995, page 3) found that about two-thirds of reported O&M expenses at US nuclear power plants are for labor, the remaining one-third being for materials and supplies.

Source: PG&E, 2003, Chapter 4.

Comment Set CC6, cont.

**San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California
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Expanded DBT and stronger defense of the onsite ISFSI	5/yr	15
Automated shutdown system	37.5/yr for 2 yrs	N/A
Emergency cooling system	37.5/yr for 2 yrs	N/A
Re-equipment of spent-fuel pools with low-density racks and transfer of excess fuel to a hardened, dispersed, onsite ISFSI	91/yr for 2 yrs; 6/yr thereafter	N/A
Enhanced capability for onsite damage control	2/yr	10
Enhanced capability for offsite emergency response	2/yr	10
Total	192.5/yr for 2 yrs; 15/yr thereafter	54.5

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1 **IX. CONCLUSIONS**

2 Q. What are your conclusions in this testimony?

3 A. Nuclear power plants are key national assets that are especially likely to be targeted by
 4 *enemies of the US. Drawing a balance between defending key assets and pursuing security*
 5 *through offensive actions is a crucial, but not always understood, aspect of homeland-*
 6 *security policy.*

7 The NRC currently requires only a light defense of US nuclear power plants and spent fuel.
 8 As a result, these facilities are vulnerable to sophisticated, determined attacks. There is a
 9 trend in decision-making circles across the US to call for enhanced defense of US nuclear
 10 power plants and spent fuel. It is therefore prudent to assume that the Diablo Canyon plant
 11 and its spent fuel will receive an enhanced defense during the coming years.

12 This testimony describes measures that would be included in a potential plan for enhanced
 13 defense of the Diablo Canyon plant and its spent fuel. These measures could be required
 14 by the NRC and/or other arms of the federal government. Preliminary estimates are made
 15 here of the additional capital and O&M expenses that would be incurred by PG&E if the
 16 measures were implemented. PG&E has not included any of these additional costs in its

Comment Set CC6, cont.

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1 | cost-benefit analyses, assuming instead a zero probability of additional requirements for an
2 | enhanced defense during the operational life of the Diablo Canyon plant and its spent fuel
3 | storage. Such an assumption is not appropriate, and the costs that I have estimated should
4 | be considered in evaluating PG&E's application.

CC6-111

Comment Set CC6, cont.

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Appendix A: Curriculum Vitae for Gordon Thompson (August 2003)

Professional expertise

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

Current appointments

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

Education

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

Project sponsors and tasks (selected)

- STAR Foundation, New York, 2002-2003: reviewed planning and actions for decommissioning of research reactors at Brookhaven National Laboratory.
- Attorney General of Utah, 2003: conducted technical analysis on a proposed storage facility for spent nuclear fuel.
- Mothers for Peace, California, 2002-2003: analyzed risk issues associated with the Diablo Canyon nuclear power plant; prepared a Call for Action to protect US nuclear power plants and spent fuel.
- Citizens Awareness Network, Massachusetts, 2002-2003: conducted analysis on robust storage of spent nuclear fuel.
- Tides Center, California, 2002-2003: 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.
- William and Flora Hewlett Foundation and other sponsors, 1999-2003: 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.
- Massachusetts Water Resources Authority, 2000: evaluated risks associated with water supply and wastewater systems that serve greater Boston.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

- 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 review of a major foundation's grant-making related to climate change.
- UN High Commissioner for Refugees, 1998: developed a strategy for conflict management in the CIS region.
- General Council of County Councils (Ireland), W. Alton Jones Foundation (USA), and Nuclear Free Local Authorities (UK), 1996-2000: 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).
- International Physicians for the Prevention of Nuclear War, 1993-1994: a study on the international control of weapons-usable fissile material.
- Government of Lower Saxony, Hannover, Germany, 1993: analysis of standards for radioactive waste disposal.
- University of Vienna (using funds supplied by the Austrian government), 1992: review of radioactive waste management at the Dukovany nuclear plant, Czech Republic.
- Sandia National Laboratories, 1992-1993: advice to the US Department of Energy's Office of Foreign Intelligence.
- US Department of Energy and Battelle Pacific Northwest Laboratories, 1991-1992: advice for the Intergovernmental Panel on Climate Change regarding the design of an information system on technologies that can limit greenhouse gas emissions (joint project of IRSS, Clark University and the Center for Strategic and International Studies).
- Winston Foundation for World Peace, Boston, 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.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

- 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: analysis of risk aspects of a proposed radioactive waste repository at Hanford.
- Natural Resources Defense Council, Washington, DC, 1986-1987: preparation of testimony on hazards of the Savannah River Plant.
- Lakes Environmental Association, Bridgton, 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.
- Three Mile Island Public Health Fund, Philadelphia, Pennsylvania, 1983-1989: studies related to the Three Mile Island nuclear power plant.
- Attorney General, Commonwealth of Massachusetts, 1984-1989: analyses of the safety of the Seabrook nuclear plant.
- 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 testimony on cogeneration potential at a Maine papermill.
- Town & Country Planning Association, London, UK, 1982-1984: coordination and conduct of a study on safety and radioactive waste implications of the proposed Sizewell nuclear plant.
- US Environmental Protection Agency, Washington, DC, 1980-1981: assessment of the cleanup of Three Mile Island Unit 2 nuclear plant.
- Center for Energy & Environmental Studies, Princeton University, Princeton, 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 aspects of the proposed Gorleben nuclear fuel cycle center.

Comment Set CC6, cont.

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Other experience (selected)

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

Publications (selected)

- "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, in press.
- *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 commissioned by Citizens Awareness Network, Shelburne Falls, Massachusetts, January 2003.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

- *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), Working Paper No. 7, 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*, Working Paper No. 165, Peace Research Centre, Australian National University, Canberra, October 1996.
- "The Potential for Cooperation by the OSCE and Non-Governmental Actors on Conflict Management" (with Paula Gutlove), *Helsinki Monitor*, Volume 6 (1995), Number 3.
- "Potential Characteristics of Severe Reactor Accidents at Nuclear Plants", "Monitoring and Modelling Atmospheric Dispersion of Radioactivity Following a Reactor Accident" (with Richard Sclove, Ulrike Fink and Peter Taylor), "Safety Status of Nuclear Reactors and Classification of Emergency Action Levels", and "The Use of Probabilistic Risk Assessment in Emergency Response Planning for Nuclear Power Plant Accidents" (with Robert Goble), in D. Golding, J. X. Kasperson and R. E. Kasperson (eds), *Preparing for Nuclear Power Plant Accidents*, Westview Press, Boulder, 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.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

- *Opportunities for International Control of Weapons-Usable Fissile Material*, ENWE Paper #1, 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*, Working Paper No. 6, 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), Working Paper No. 4, IRSS, Cambridge, Massachusetts, October 1991.
- *Regulatory Response to the Potential for Reactor Accidents: The Example of Boiling-Water Reactors*, Working Paper No. 3, IRSS, Cambridge, Massachusetts, February 1991.
- *Peace by Piece: New Options for International Arms Control and Disarmament*, Working Paper No. 1, IRSS, Cambridge, Massachusetts, January 1991.
- *Developing Practical Measures to Prevent Climate Disruption* (with Robert Goble), CENTED 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.
- *A Global Approach to Controlling Nuclear Weapons*, Occasional Paper published by 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.

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- "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*, Volume I, August 1985, published by the Proliferation Reform Project, IRSS.
- "A Turning Point for the NPT ?", *ADIU Report*, University of Sussex, Brighton, UK, Nov/Dec 1984, pp 1-4.
- "Energy Economics", in J. Dennis (ed), *The Nuclear Almanac*, Addison-Wesley, Reading, 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.
- *Utility-Scale Electrical Storage in the USA: The Prospects of Pumped Hydro, Compressed Air, and Batteries*, Princeton University report PU/CEES #120, 1981.
- *The Prospects for Wind and Wave Power in North America*, Princeton University report PU/CEES # 117, 1981.
- *Hydroelectric Power in the USA: Evolving to Meet New Needs*, Princeton University report PU/CEES # 115, 1981.
- Editing and part authorship of "Potential Accidents & Their Effects", Chapter III of *Report of the Gorleben International Review*, published in German by the Government of Lower Saxony, FRG, 1979--Chapter III available in English from the Political Ecology Research Group, Oxford, UK.
- *A Study of the Consequences to the Public of a Severe Accident at a Commercial FBR located at Kalkar, West Germany*, Political Ecology Research Group report RR-1, 1978.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

Expert presentations and testimony (selected)

- European Parliament, 2003: gave an invited presentation to members regarding safety and security issues at the Sellafield nuclear site; discussed broader implications.
- US Congress, 2002 and 2003: gave member-sponsored staff briefings on vulnerabilities of nuclear-power facilities and options for improved defenses.
- Numerous public forums in the USA, 2001-2003: gave invited presentations to public officials and general audiences regarding vulnerabilities of nuclear-power facilities and options for improved defenses.
- UK Consensus Conference on Radioactive Waste Management, 1999: provided invited testimony on information and decision-making.
- Joint Committee on Public Enterprise and Transport, Irish Parliament, 1999: provided invited testimony on nuclear fuel reprocessing and international security.
- UK and Irish Parliaments, 1998: gave members' briefings on risks and alternative options associated with nuclear fuel reprocessing in the UK.
- Center for Russian Environmental Policy, Moscow, 1996: presentation at a forum in parallel with the G-7 Nuclear Safety Summit.
- Lacey Township Zoning Board, New Jersey, 1995: testimony regarding radioactive waste management.
- Ontario Court of Justice, Toronto, Ontario, 1993: testimony regarding Canada's Nuclear Liability Act.
- Oxford Research Group, seminar on "The Plutonium Legacy", Rhodes House, Oxford, UK, 1993: presentation on nuclear safeguards.
- Defense Nuclear Facilities Safety Board, Washington, DC, 1991: testimony regarding the proposed restart of K-reactor, Savannah River Site.
- Conference to consider amending the Partial Test Ban Treaty, United Nations, New York, 1991: presentation on a global approach to arms control and disarmament.
- US Department of Energy, hearing on draft EIS for new production reactor capacity, Columbia, South Carolina, 1991: presentation on tritium need and implications of tritium production options.
- Society for Risk Analysis, 1990 annual meeting, New Orleans, special session on nuclear emergency planning: presentation on real-time techniques for anticipating emergencies.
- Parliamentarians' Global Action, 11th Annual Parliamentary Forum, United Nations, Geneva, 1990: presentation on the potential for multilateral nuclear arms control.
- Advisory Committee on Nuclear Facility Safety, public meeting, Washington, DC, 1989: submission on public access to information and on government accountability.
- Peace Research Centre, Australian National University, seminar on "Australia and the Fourth NPT Review Conference", Canberra, 1989: proposal of a universal nuclear weapons non-proliferation regime.
- Carnegie Endowment for International Peace, Conference on "Nuclear Non-Proliferation and the Role of Private Organizations", Washington, DC, 1989: options for reform of the non-proliferation regime.
- US Department of Energy, EIS scoping hearing, Columbia, South Carolina, 1988: appropriate scope of an EIS for new production reactor capacity.

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

- International Physicians for the Prevention of Nuclear War, 6th and 7th Annual Congresses, Koln, FRG, 1986 and Moscow, USSR, 1987: relationships between nuclear power and the threat of nuclear war.
- County Council, Richland County, South Carolina, 1987: implications of severe reactor accidents at the Savannah River Plant.
- Maine Land Use Regulation Commission, 1985: cogeneration potential at facilities of Great Northern Paper Company.
- Interfaith Hearings on Nuclear Issues, Toronto, Ontario, 1984: options for Canada's nuclear trade and Canada's involvement in nuclear arms control.
- Sizewell Public Inquiry, UK, 1984: safety and radioactive waste implications of the proposed Sizewell nuclear plant.
- New Hampshire Public Utilities Commission, 1983: electricity demand and supply options for New Hampshire.
- Atomic Safety & Licensing Board, US Nuclear Regulatory Commission, 1983: use of filtered venting at the Indian Point nuclear plants.
- US National Advisory Committee on Oceans and Atmosphere, 1982: implications of ocean disposal of radioactive waste.
- Environmental & Energy Study Conference, US Congress, 1982: implications of radioactive waste management.

Miscellaneous

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

Contact information

Institute for Resource and Security Studies
27 Ellsworth Avenue, Cambridge, Massachusetts 02139, USA
Phone: 617-491-5177 Fax: 617-491-6904 E-mail: ghompson@irss-usa.org

Comment Set CC6, cont.

San Luis Obispo Mothers for Peace, Sierra Club, Public Citizen, and Environment California (the "Joint Parties")

Appendix B: Bibliography

(Alvarez et al, 2003)

Robert Alvarez and seven other authors, "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States", Science and Global Security, 11:1-51, 2003.

(AT, 2004)

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(Baker, Cutler et al, 2001)

Howard Baker and Lloyd Cutler (co-chairs, Russia Task Force) et al, A Report Card on the Department of Energy's Nonproliferation Programs with Russia (Washington, DC: Secretary of Energy Advisory Board, US Department of Energy, 10 January 2001).

(Barami, 2004)

Bahar Barami (senior economist, Volpe Center), "Market Trends in Homeland Security Technologies", paper presented at the IEEE Conference on Technologies for Homeland Security, Volpe Center, Cambridge, Massachusetts, 21-24 April 2004.

(Beyea et al, 2004)

Jan Beyea, Ed Lyman and Frank von Hippel, "Damages from a Major Release of 137Cs into the Atmosphere of the United States", Science and Global Security, 12:125-136, 2004.

(Beyea et al, 1979)

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.

(Brian, 2003)

Danielle Brian (executive director, Project on Government Oversight), speech to the NRC's Regulatory Information Conference, 16 April 2003, available at <http://www.pogo.org/p/environment/et-030401-nuclear.html>, accessed on 24 May 2003.

(Chapin et al, 2002)

Douglas M. Chapin et al, "Nuclear Power Plants and Their Fuel as Terrorist Targets", Science, Volume 297, 20 September 2002, pp 1997-1999.

(Clover, 2004)

Charles Clover, "Natural-born killers will not win hearts and minds", Financial Times, 25 June 2004.

(Collins et al, 2000)

Comment Set CC6, cont.

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Timothy Collins et al, Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (Washington, DC: US Nuclear Regulatory Commission, October 2000).

(Conley, 2004)

Maureen Conley, "Holtec to ask NRC to approve underground design for dry storage facility", Nuclear Fuel, 26 April 2004, pages 1 and 11.

(Deller, 2002)

Nicole Deller, "Rule of Power or Rule of Law?", Science for Democratic Action, Volume 10, Number 4, August 2002.

(Diaz, 2003)

Nils J. Diaz (chairman, US Nuclear Regulatory Commission), letter of 23 October 2003 to US Representative Edward J. Markey.

(Dillingham, 2003)

Gerald L. Dillingham (US General Accounting Office), Testimony before the Committee on Commerce, Science and Transportation, US Senate, Aviation Security: Progress Since September 11, 2001, and the Challenges Ahead, 9 September 2003.

(DOE, 2002)

US Department of Energy, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250F (Washington, DC: DOE, February 2002).

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US Department of Energy, Health and Environmental Consequences of the Chernobyl Nuclear Power Plant Accident, DOE/ER-0332 (Washington, DC: DOE, June 1987).

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Thoralf Doehring, Mk-15 Phalanx Close-In Weapons System, Doehring personal website (navysite.de/weapons/phalanx.htm), accessed on 16 June 2004.

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Defense Security Cooperation Agency, News Release, Egypt – AN/MPO-64 SENTINEL Radar Systems, 4 September 2002.

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Energy Information Administration, US Department of Energy, An Analysis of Nuclear Power Plant Operating Costs: A 1995 Update (Washington, DC: EIA, April 1995).

(ElBaradei, 2004)

Mohamed ElBaradei (director general, International Atomic Energy Agency), "Nuclear Non-Proliferation: Global Security in a Rapidly Changing World", keynote address, Carnegie International Non-Proliferation Conference, Washington, DC, 21 June 2004.

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(Ewing and Macfarlane, 2002)

Rodney C. Ewing and Allison Macfarlane, "Yucca Mountain", Science, Volume 296, 26 April 2002, pp 659-660.

(FAS, 2003)

FAS Military Analysis Network, MK 15 Phalanx Close-In Weapons System (CIWS), Federation of American Scientists website (www.fas.org/man/dod-101), updated on 9 January 2003.

(FAS, 2000a)

FAS Military Analysis Network, AN/MPQ-64 Sentinel, Forward Area Air-Defense Ground Based Sensor (FAAD-GBS), Federation of American Scientists website (www.fas.org/man/dod-101), updated on 29 May 2000.

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FAS Military Analysis Network, Avenger (Pedestal Mounted Stinger), Federation of American Scientists website (www.fas.org/man/dod-101), updated on 5 May 2000.

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FAS Military Analysis Network, FIM-92A Stinger Weapons System: RMP & Basic, Federation of American Scientists website (www.fas.org/man/dod-101), updated on 9 August 2000.

(Ford, 1982)

Daniel Ford, Cult of the Atom (New York, New York: Simon and Schuster, 1982).

(Friedman, 1991)

Norman Friedman, The Naval Institute Guide to World Naval Weapons Systems 1991/92 (Annapolis, Maryland: Naval Institute Press, 1991).

(Gale and Husick, 2003)

Stephen Gale and Lawrence Husick, "From MAD (Mutual Assured Destruction) to MUD (Mutual Unconstrained Disruption): Dealing with the New Terrorism", Foreign Policy Research Institute Wire, Volume 11, Number 1, February 2003.

(Glanz, 2004)

James Glanz, "15 Miles Offshore, Safeguarding Iraq's Oil Lifeline", New York Times, 6 July 2004.

(Goff, 2003)

Stanley A Goff, Predeployed Radiological Weapon: Reducing the targetability of Shearon Harris Nuclear Plant and the risk to the North Carolina public (Durham, North Carolina: NC-WARN, 1 May 2003).

Comment Set CC6, cont.

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Dominic Golding et al, Managing Nuclear Accidents: A Model Emergency Response Plan for Power Plants and Communities (Boulder, Colorado: Westview Press, 1992).

(Hannerz, 1983)

K. Hannerz, Towards Intrinsically Safe Light Water Reactors (Oak Ridge, Tennessee: Institute for Energy Analysis, February 1983).

(Hart et al, 2002)

Gary Hart and Warren B. Rudman (co-chairs), Stephen E. Flynn (project director) and Task Force members, America Still Unprepared -- America Still in Danger: Report of an Independent Task Force Sponsored by the Council on Foreign Relations (New York, NY: Council on Foreign Relations, 25 October 2002).

(HCDC, 2002)

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CERTIFICATE OF SERVICE

I, Jack McGowan, certify that I have, on this date, caused the foregoing TESTIMONY OF GORDON THOMPSON ON BEHALF OF THE SAN LUIS OBISPO MOTHERS FOR PEACE, SIERRA CLUB, PUBLIC CITIZEN, GREENPEACE AND ENVIRONMENT CALIFORNIA to be served by electronic mail on the parties listed on the Service List, and by U.S. Mail for those who have not provided an electronic address, for the proceeding in California Public Utilities Commission Docket No. A.04-01-009.

I declare under penalty of perjury, pursuant to the laws of the State of California, that the foregoing is true and correct.

Executed on August 3, 2004, 2004 in San Francisco, California.

Jack McGowan