September 14, 2007

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Pa'ina Hawaii, LLC	)	Docket No. 30-36974-ML
	)	ASLBP No. 06-843-01-ML
Material License Application	)	
	)	

INTERVENOR CONCERNED CITIZENS OF HONOLULU'S CONTENTIONS RE: FINAL SAFETY EVALUATION REPORT

I. INTRODUCTION

Pursuant to 10 C.F.R. § 2.309(c) and (f)(2) and this Board's May 1, 2006 order, intervenor Concerned Citizens of Honolulu hereby files contentions related to the Final Safety Evaluation Report ("SER") (ADAMS Accession No. ML072260186).[1] In previously filed contentions, Concerned Citizens challenged the adequacy of the analysis in the Final Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Pa'ina Hawaii, LLC Irradiator Facility ("Final Topical Report") (ADAMS Accession No.

[1] While Concerned Citizens believes section 2.309(f)(2) alone provides adequate authority to file contentions addressing the SER, which was not available at the time its original petition had to be filed, in an abundance of caution, Concerned Citizens will also address herein the factors set forth in section 2.309(c). See Entergy Nuclear Vermont Yankee, LLC, and Entergy Nuclear Operations, Inc. (Vermont Yankee Nuclear Power Station), LBP-04-28, 60 NRC 548, 578 (2004) (noting section 2.309(c) and (f)(2) provide alternate means for intervenor to file new contention where subsequently filed document "provides information 'not previously available' that is 'materially different'"); see also id. at 567 n.24 ("If new and materially different information later comes to light, we may entertain a motion for leave to file a new contention under 10 C.F.R. § 2.309(f)(2)"); 6/22/06 Board Order (Ruling on Admissibility of Two Amended Contentions) at 4 (new or amended contentions "evaluated using the applicable factors set forth in 10 C.F.R. § 2.309(c)" only if "not filed in a 'timely fashion' under 10 C.F.R. § 2.309(f)(2)(iii)"); 1/25/07 Board Order (Rejecting Motion to Dismiss) at 5 ("contention proffered at this stage in the proceeding" must satisfy 10 C.F.R. § 2.309(f)(2)).

ML071280833). While the Final Topical Report's treatment of threats to safety from aviation accidents and natural disasters was deficient, the report at least discussed them. In contrast, the SER virtually ignores them, making no mention of safety threats from airplane crashes, tsunamis or hurricanes and including only a cursory and wholly inadequate discussion of the potential for earthquake damage. Consequently, the SER cannot support the Nuclear Regulatory Commission ("NRC") Staff's conclusion that Pa'ina Hawaii, LLC has demonstrated its proposed irradiator would "protect health and minimize danger to life or property," as required by 10 C.F.R. § 30.33(a)(2).

Concerned Citizens files these contentions "to raise specific challenges regarding the new information" in the SER. Duke Energy Corp. (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-28, 56 NRC 373, 383 (2002). The Board should admit these contentions since the issues they raise regarding the failure to demonstrate compliance with 10 C.F.R. § 30.33(a)(2) are central "to the findings the NRC must make to support the action that is involved in the proceeding," and Concerned Citizens otherwise satisfies all requirements for filing these contentions. 10 C.F.R. § 2.309(f)(1)(iv).

II. PROCEDURAL AND FACTUAL BACKGROUND[2]

On October 3, 2005, Concerned Citizens timely filed a request for hearing on Pa'ina's application for a license for possession and use of byproduct material in connection with the construction and operation of a commercial pool-type industrial irradiator using a cobalt-60 ("Co-60") source at the Honolulu International Airport. Among other issues, Concerned Citizens' hearing request included contentions regarding Pa'ina's failure to address threats from

[2] The facts of this case have been set forth in detail several times. Accordingly, Concerned Citizens will focus here on only those facts most relevant to the safety contentions set forth herein.

natural disasters and aviation accidents (Safety Contentions #6 & #7) and the NRC's failure to comply with the National Environmental Policy Act (Environmental Contentions #1 & #2). 10/3/05 Hearing Request at 10, 15, 19-25; 12/1/05 Reply in Support of Hearing Request at 18.

On January 24, 2006, the Board granted Concerned Citizens' request for hearing, finding Concerned Citizens had standing and finding admissible its two environmental contentions. Pa'ina Hawaii, LLC (Material License Application), LBP-06-04, 63 NRC 99 (2006).

On March 24, 2006, the Board issued an order admitting three of Concerned Citizens' safety contentions, including Safety Contentions #6 and #7. Pa'ina Hawaii, LLC (Material License Application), LBP-06-12, 63 NRC 403, 418, 420 (2006). On June 22, 2006, following Pa'ina's submission of emergency procedures regarding natural disasters, the Board dismissed Safety Contention #6. 6/22/06 Board Order at 15.

Following issuance of the Draft and Final Topical Reports, Concerned Citizens timely filed contentions that these documents fail to satisfy 10 C.F.R. § 30.33(a)(2)'s requirement to demonstrate the proposed irradiator would be safe in the event of an aviation accident, tsunami, hurricane or earthquake. See 2/9/07 Contentions; 6/1/07 Amended Safety Contentions. The Board has not yet ruled on the admissibility of these contentions. On August 31, 2007, the Board certified to the Commission the question "whether, in the circumstances presented, 10 C.F.R. § 30.33(a)(2) requires a safety analysis of the risks asserted to be endemic (i.e. aircraft crashes and natural phenomena) to the proposed irradiator site at the Honolulu International Airport." 8/31/07 Board Memorandum at 1 (Certifying Question to the Commission).

On August 17, 2007, the Staff issued NRC License No. 53-29296-01 to Pa'ina for possession and use of sealed sources in its proposed irradiator. ML072260171; ML072320269. Pursuant to 10 C.F.R. § 2.1202(a), the Staff sent notice of the license's issuance to Concerned

Citizens on August 20, 2007. ML072320384. On August 27, 2007, Concerned Citizens timely filed an application for a stay of the license's issuance. See 10 C.F.R. § 2.1213(a).

On August 21, 2007, the Staff served the SER on Concerned Citizens. Exh. 1: 8/21/07 Clark Email. Concerned Citizens now addresses the new information in the SER by submitting timely contentions pursuant to 10 C.F.R. § 2.309(c) and (f)(2) and this Board's May 1, 2006 order. See 5/1/06 Board Order at 2 (late-filed contentions relating to SER due within thirty days of its issuance).

III. THE SER FAILS TO ESTABLISH PA'INA'S PROPOSED IRRADIATOR WOULD "PROTECT HEALTH AND MINIMIZE DANGER TO LIFE OR PROPERTY" IN THE EVENT OF AN AVIATION ACCIDENT OR NATURAL DISASTER, AS REQUIRED BY 10 C.F.R. § 30.33(a)(2)

In the SER, the Staff sets forth its determination "that the application satisfies all NRC's [sic] requirements in," inter alia, "10 CFR Part 30" and, on the basis of that determination, "concludes that a license can be issued to Pa'ina Hawaii, LLC, for the possession and use of licensed material in an irradiator." SER at 6. As discussed below, the SER lacks adequate information to support the Staff's finding Pa'ina has established its proposed irradiator would be "adequate to protect health and minimize danger to life or property," as required by 10 C.F.R. § 30.33(a)(2). The SER contains no discussion whatsoever of the elevated risk of aviation accidents, tsunamis and hurricanes at Pa'ina's proposed site and relies on inaccurate and incomplete information to conclude the facility would be safe in the event of an earthquake.

A. Safety Contention #15: The SER Fails To Evaluate Safety Risks From Aviation Crashes, Tsunamis and Hurricanes.

The evidence in the hearing file establishes that the site where Pa'ina proposes to construct and operate its irradiator faces unique threats from aviation accidents, tsunamis and

hurricanes. Due to the site's proximity to active runways at Honolulu International Airport, the irradiator would face an extremely elevated risk of being struck by an airplane, with the annual likelihood of the facility being involved in such an accident ranging from one-in-5,000 to one-in-1,757. See Final Topical Report at 2-18; Exh. 2: 2/9/07 Resnikoff Dec. ¶¶ 10-11; Exh. 3: 2/7/07 Resnikoff Report. Due to its low elevation and proximity to Keʻehi Lagoon, the proposed site, which lies within the tsunami evacuation zone, is susceptible to flooding by tsunamis and hurricanes, as well as to wind damage by hurricanes. Exh. 4: 2/9/07 Pararas-Carayannis Dec. ¶¶ 12-29; Exh. 5: 2/07 Pararas-Carayannis Report.

The numerous expert declarations and reports Concerned Citizens has filed in this proceeding highlight the potential for aviation accidents, tsunamis and hurricanes involving the proposed irradiator to result in radiation releases posing threats to the people and environment of Honolulu. See, e.g., 2/9/07 Resnikoff Dec. ¶¶ 15-19 (discussing potential consequences of aviation accident); Exh. 6: 2/8/07 Sozen Dec. ¶ 7 (same); Exh. 7: 2/1/07 Sozen/Hoffmann Report (same); Exh. 8: 8/24/07 Resnikoff Dec. ¶¶ 7-15 (same); 2/9/07 Pararas-Carayannis Dec. ¶¶ 15, 19, 22, 31 (discussing potential consequences of tsunamis and hurricanes). Incredibly, the SER fails even to mention – much less evaluate – these potential safety threats. Consequently, the Staff had no basis to determine whether the design of Paʻina's proposed irradiator would be adequate "to protect health and minimize danger to life or property" in the event such a catastrophe were to occur, as required by 10 C.F.R. § 30.33(a)(2).

Merely ensuring Paʻina's application complies with NUREG-1556, Volume 6, does not, as the SER suggests, discharge the Staff's obligation to ensure the irradiator's safety. SER at 2. NUREG-1556 addresses only the specific requirements of 10 C.F.R. Part 36, providing a checklist to help the Staff determine whether an irradiator application contains certain specified

information. See NUREG-1556, "Consolidated Guidance About Materials Licenses," Vol. 6, "Program Specific Guidance About 10 CFR Part 36 Irradiator Licenses" at 8-1 to 8-59 & app. C (1999). The regulations applicable to irradiators make clear that, before a materials license application can be approved, the applicant must "satisfy the general requirements specified in § 30.33 of this chapter," which include section 30.33(a)(2), in addition to satisfying "the requirements contained in [Part 36]." 10 C.F.R. § 36.13(a); see also United States v. Bucher, 375 F.3d 929, 933 (9th Cir. 2004) (regulations must "be read so that none of [their] terms are rendered redundant"). While compliance with Part 36's requirements is necessary to secure an irradiator license, it is not sufficient. Pa'ina must, in addition, demonstrate its proposed irradiator is "adequate to protect health and minimize danger to life or property." 10 C.F.R. § 30.33(a)(2).

In issuing a license based on an SER that fails to evaluate safety threats from aviation accidents, tsunamis and hurricanes, the Staff illegally failed to ensure Pa'ina's compliance with section 30.33(a)(2).

B. Safety Contention #16: The SER Inadequately Analyzes Safety Risks From Earthquakes.

While the SER mentions potential soil liquefaction and other issues related to earthquakes, its cursory analysis is wholly inadequate to support a finding Pa'ina's proposed irradiator would be safe. 9/12/07 Pararas-Carayannis Dec. ¶ 5. Initially, the SER states that "the factor of safety against liquefaction would be in an acceptable range as long as the Standard Penetration Test (SPT) blowcount from the soil boring was of an adequate value." SER at 4. While this statement is accurate as a general proposition, the SER fails to consider whether, in fact, the SPT blow counts reported from soil borings at the proposed irradiator site are, in fact,

"of an adequate value." 9/12/07 Pararas-Carayannis Dec. ¶ 6. Review of Pa'ina's September 14, 2005 geotechnical report (ADAMS Accession No. ML053460276) reveals the recorded blow counts are far from adequate to ensure against damage from liquefaction. Id. ¶¶ 6-10.

The site Pa'ina has proposed for its irradiator is on reclaimed land that has been filled with non-homogeneous, unconsolidated alluvial material, most of which was dredged from the existing waterway of Ke'ehi Lagoon. Id. ¶ 9. The density of material, the granular composition, silt content, and the particle size distribution vary, as well as the degree of settling. Id. This is why the blow count values presented in the geotechnical report vary so much, with values ranging from 4 to 120. Id.; see also 9/14/05 Geotechnical Report at Plate Nos. A3-A7.

Many of the geotechnical report's blow count values recorded were below 15, indicating a substantial risk of liquefaction from an earthquake. 9/12/07 Pararas-Carayannis Dec. ¶ 10; see also 9/14/05 Geotechnical Report at Plate Nos. A3-A7. Indeed, with such low blow counts, an earthquake would not have to be particularly significant to cause liquefaction. 9/12/07 Pararas-Carayannis Dec. ¶ 10. Depending on the epicenter, depth and directional focusing, even a relatively small event could result in liquefaction, presenting significant safety concerns since, in addition to the low blow count values, the site has groundwater only a few feet below the surface. Id. The material below the Pa'ina site (silty sands and gravel) is supersaturated with water, and there could be at least partial – if not total – liquefaction at the toe of any structure built on such a site. Id. Consequently, the SER's apparent assumption that the blow counts at the site are "of an adequate value" to ensure against liquefaction lacks any basis. Id.; see also id. ¶ 13.

The SER's conclusion that the six-inch separation between the sides of the irradiator pool and the building slab "should provide adequate isolation" in the event of an earthquake is

similarly unsubstantiated. SER at 4; see also 9/12/07 Pararas-Carayannis Dec. ¶ 11. The SER bases this finding on inaccurate assumptions about what constitutes "a seismic event typical of the area." SER at 4. The Staff has improperly trivialized the potential intensity of ground motions at the proposed irradiator site, inaccurately assuming that the Modified Mercalli Intensity V estimated for the island of O'ahu for the October 2006 earthquake is the maximum earthquake ground force that can be expected at the proposed site. 9/12/07 Pararas-Carayannis Dec. ¶ 11; see also Final Topical Report at 3-3. The Staff improperly ignored the fact that the Lana'i earthquake of 1871, the Maui earthquake of 1938, and the 1948 earthquake offshore of Honolulu all produced greater than Force V Intensities, with the 1871 event reported to have caused damage to every building at the Punahou School Campus. See 9/12/07 Pararas-Carayannis Dec. ¶ 11; Final Topical Report at 3-3.

Unlike magnitude, which represents a single quantity of an earthquake's energy release, intensity does not have one single value for a given earthquake. 9/12/07 Pararas-Carayannis Dec. ¶ 12. Rather, it can vary significantly from place to place depending on substrata soil conditions. Id. There is no evidence the Modified Mercalli Intensity estimate on which the Staff relied took into account the properties of unconsolidated sediments like those found at the irradiator site. Id. Similarly, the potential horizontal seismic ground motions on which the Staff relied represent statistical estimates for the southern coast of O'ahu which may not be valid for the alluvial material at the proposed facility site. Id. In addition, the Staff failed to consider the potential focusing effects of seismic energy on O'ahu. Id. Due to the flaws in the underlying analysis, there is no basis for the SER's assumption about what constitutes "a seismic event typical of the area," casting serious doubt on its conclusion the irradiator design would provide

"adequate isolation" in the event of an earthquake. SER at 4; see also 9/12/07 Pararas-Carayannis Dec. ¶ 12.

The SER fails altogether to address the situation in which the irradiator pool is damaged as a result of an earthquake, resulting in radiation exposures above regulatory limits. Since the depth of the water table is eight feet below the facility floor, the SER should have analyzed the potential for a rupture in the pool lining causing shielding water to drain to that level, which would result in a dose at the facility floor level of 14 rem/hour, nearly three times the annual occupational dose limit of 5,000 millirem/year. See Final Topical Report at 1-2; 8/24/07 Resnikoff Dec. ¶ 13; 10 C.F.R. § 20.1201(a)(1)(i).

Additional analysis is needed before the Staff can make a defensible assessment whether the proposed irradiator would be safe in the event of an earthquake, as 10 C.F.R. § 30.33(a)(2) requires. 9/12/07 Pararas-Carayannis Dec. ¶ 14.

IV. CONCERNED CITIZENS' CONTENTIONS SATISFY THE REQUIREMENTS FOR ADMISSION

A. The Contentions Satisfy 10 C.F.R. § 2.309(f)(1).

In the foregoing discussion, Concerned Citizens has provided specific statements of the factual and legal issues to be raised, a brief explanation of the basis for each contention, and a concise statement of the alleged facts and expert opinions which support Concerned Citizens' position on the issues and on which Concerned Citizens intends to rely at hearing, as required by 10 C.F.R. § 2.309(f)(1)(i), (ii) and (v). The core issue raised by these safety contentions – whether the SER fails to support the Staff's finding Pa'ina carried its burden to ensure adequate protection for the public and environment in the event of aviation accidents or natural disasters involving the proposed irradiator – is within the scope of this proceeding and material to the

findings the Board must make herein. See id. § 2.309(f)(1)(iii)-(iv); see also LBP-06-12, 63 NRC at 420 (Board must ensure compliance with 10 C.F.R. § 30.33(a)(2)). By pointing out the specific portions of the SER it claims are deficient, as well as necessary information and analyses that that document fails to provide, Concerned Citizens has established its contentions present genuine disputes on material issues in accordance with 10 C.F.R. § 2.309(f)(1)(vi).

B. The Contentions Satisfy 10 C.F.R. § 2.309(f)(2).

Concerned Citizens' contentions challenge omissions and other deficiencies in the SER's analysis of the effects of natural phenomena and aviation accidents at Pa'ina's proposed irradiator. While the Draft and Final Topical Reports also addressed these potential impacts, the SER's analysis differs in material respects, and Concerned Citizens seeks to amend its contentions to address only those differences. Prior to the Staff's service of the SER on August 21, 2007, the information upon which the proffered safety contentions are based "was not previously available," and that information "is materially different than information previously available," in conformity with 10 C.F.R. § 2.309(f)(2)(i) and (ii). See Henkin Dec. ¶ 3.

In accordance with the Board's May 1, 2006 order, Concerned Citizens filed its contentions regarding the SER within thirty days of the availability of this document, and, accordingly, the contentions are "timely." 10 C.F.R. § 2.309(f)(2)(iii); see also 5/1/06 Board Order at 2.

C. 10 C.F.R. § 2.309(c).

As discussed footnote 1, supra, Concerned Citizens does not believe consideration of 10 C.F.R. § 2.309(c) is required before the Board can admit timely filed contentions related to the deficiencies of documents submitted long after the original hearing petition had to be filed.

However, even if section 2.309(c)'s factors were relevant to the Board's decision, the Board still should admit the contentions. In analyzing contentions pursuant to section 2.309(c), "each factor is not necessarily applicable to the present case, nor is it necessary or appropriate to assign each factor equal weight." 6/22/06 Board Order at 13. "Rather, the first factor, 'good cause,' is the most important factor." Id.

In this case, new information regarding the Staff's analysis of important safety issues – or lack thereof – was presented in the SER, and Concerned Citizens "could not have possibly challenged facts or analyses that were not presented" at the time it filed its original hearing request. 1/25/07 Board Order at 3-4. Since the SER "provides entirely new information," Concerned Citizens could not have challenged the adequacy of its analysis prior to the time the Staff provided it to the parties on August 21, 2007, and, thus, had good cause for not filing its contentions earlier. Id. at 4; see also Entergy Nuclear Vermont Yankee, LLC, and Entergy Nuclear Operations, Inc. (Vermont Yankee Nuclear Power Station), LBP-04-33, 60 NRC 749, 754 (2004) (citing Consumers Power Co. (Midland Plant, Units 1 and 2), LBP-82-63, 16 NRC 571, 577 (1982)) ("Newly available material information has long been held to provide good cause to file a new contention").

The Board has previously held Concerned Citizens has standing to participate in this proceeding under either traditional judicial concepts of standing or proximity-plus standing, due to the "obvious potential for offsite consequences from the significant source of radioactivity housed within the irradiator." LBP-06-04, 63 NRC at 107. Since the Board has already found Concerned Citizens' "interest may be affected by this proceeding," and no party has appealed that decision, Concerned Citizens unquestionably has a right to participate in this licensing proceeding. Id. at 103 (quoting 42 U.S.C. § 2239(a)(1)(A)); see also 10 C.F.R. § 2.309(c)(ii).

As for the nature and extent of its "interest in the proceeding," it is to avoid or minimize threats of injury from radiation exposure associated with the irradiator, including exposures that could result from the types of accidents and other incidents the SER is supposed to, but failed to, address. 10 C.F.R. § 2.309(c)(iii).

"The proposed irradiator will not be operated without approval and a license from the NRC." LBP-06-04, 63 NRC at 105. Consequently, whether and the degree to which Concerned Citizens and its members face threats of injury from radiation is completely contingent on the ultimate decision on Pa'ina's license application. Since the hearing on this application is the only forum in which Concerned Citizens can seek to ensure Pa'ina's compliance with 10 C.F.R. § 30.33(a)(2), the factors set forth in section 2.309(c)(iv) and (v) weigh in favor of admitting the proffered contentions.

The Staff is itself the author of the deficient SER, and there are no other intervenors in this case. Thus, there are no other existing parties who will or can represent Concerned Citizens' interests. See 10 C.F.R. § 2.309(c)(vi).

Admitting the proffered contentions would not broaden the issues in this licensing proceeding, since, with or without the contentions, the Board would be obliged to consider whether Pa'ina's proposed irradiator would adequately protect the public and environment from aviation accidents and natural disasters. See 10 C.F.R. § 2.309(c)(vii). While allowing Concerned Citizens to present evidence and argument regarding its contentions may increase the time necessary to complete the licensing proceeding, that factor alone does not militate against admitting the contentions. The primary effect of admitting the contentions would be to ensure the Board has a fully developed and sound record on which to base its ultimate decision, with

Concerned Citizens' experts providing information that otherwise would be missing from the proceeding. See id. § 2.309(c)(viii).

V. CONCLUSION

For the foregoing reasons, Concerned Citizens respectfully asks the Board to admit the contentions regarding the SER presented herein.

Dated at Honolulu, Hawai'i, September 14, 2007.

Respectfully submitted,

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Pa'ina Hawaii, LLC Materials License Application	)))))	Docket No. 30-36974-ML ASLBP No. 06-843-01-ML

DECLARATION OF DAVID L. HENKIN

I, David L. Henkin, declare:

1. I am an attorney at law, duly licensed to practice before all courts of the State of Hawai'i, the U.S. District Court for the District of Hawai'i, the U.S. Court of Appeals for the 9th Circuit, and the U.S. Supreme Court. I am the lead attorney for intervenor Concerned Citizens of Honolulu.

2. I make this declaration in support of Concerned Citizens' Contentions Re: Final Safety Evaluation Report. This declaration is based on my personal knowledge, and I am competent to testify about the matters contained herein.

3. Attached hereto as Exhibit "1" is a true and correct copy of an email that Michael Clark, counsel to the Nuclear Regulatory Commission Staff, sent on August 21, 2007, transmitting a copy of the final Safety Evaluation Report ("SER"). Mr. Clark was responding to an email I had sent to him on August 20, 2007, noting that the SER was not available on ADAMS or in the hearing file.

4. Attached hereto as Exhibit "2" is a true and correct copy of the February 9, 2007 Declaration of Marvin Resnikoff, Ph.D. In Support Of Concerned Citizens' Contentions Re:

Draft Environmental Assessment And Draft Topical Report, which Concerned Citizens filed herein on February 9, 2007.

5. Attached hereto as Exhibit "3" is a true and correct copy of Dr. Resnikoff's February 7, 2007 report entitled "The Probability of Aircraft Impact into the Proposed Pa'ina Hawaii Irradiator." Concerned Citizens submitted a copy of this report with its February 8, 2007 comments on the draft environmental assessment ("Draft EA") and filed it as Exhibit "1" in support of its February 9, 2007 Contentions Re: Draft Environmental Assessment And Draft Topical Report.

6. Attached hereto as Exhibit "4" is a true and correct copy of the February 9, 2007 Declaration of George Pararas-Carayannis, Ph.D. In Support Of Concerned Citizens' Contentions Re: Draft Environmental Assessment And Draft Topical Report, which Concerned Citizens filed herein on February 9, 2007.

7. Attached hereto as Exhibit "5" is a true and correct copy of Dr. Pararas-Carayannis's February 2007 report entitled "Assessment of Natural Disaster Risks for the Proposed Site of Pa'ina Hawaii, LLC's Cobalt-60 Irradiator Facility At 192 Palekona Street, Honolulu, Hawai'i." Concerned Citizens submitted a copy of this report with its February 8, 2007 comments on the Draft EA and filed it as Exhibit "9" in support of its February 9, 2007 Contentions Re: Draft Environmental Assessment And Draft Topical Report.

8. Attached hereto as Exhibit "6" is a true and correct copy of the February 8, 2007 Declaration of Mete A. Sozen, Ph.D. In Support Of Concerned Citizens' Contentions Re: Draft Environmental Assessment And Draft Topical Report, which Concerned Citizens filed herein on February 9, 2007

9. Attached hereto as Exhibit "7" is a true and correct copy of Dr. Sozen's and Dr. Christoph Hoffmann's February 1, 2007 report entitled "Analysis of the Effect of Impact by an Aircraft on a Steel Structure Similar to the Proposed Pa'ina Irradiator." Concerned Citizens submitted a copy of this report with its February 8, 2007 comments on the Draft EA and filed it as Exhibit "6" in support of its February 9, 2007 Contentions Re: Draft Environmental Assessment And Draft Topical Report.

10. Attached hereto as Exhibit "8" is a true and correct copy of the August 24, 2007 Declaration of Marvin Resnikoff, Ph.D. In Support Of Concerned Citizens' Contentions Re: Final Environmental Assessment, including Exhibit "10" thereto, which Concerned Citizens filed herein on September 4, 2007.

I declare under penalty of perjury that I have read the foregoing declaration and know the contents thereof to be true of my own knowledge.

Dated at Honolulu, Hawai'i, September 14, 2007.

DAVID L. HENKIN

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Pa'ina Hawaii, LLC	)	Docket No. 30-36974-ML
	)	ASLBP No. 06-843-01-ML
Materials License Application	)	
______________________________	)	

DECLARATION OF GEORGE PARARAS-CARAYANNIS, Ph.D. IN SUPPORT OF CONCERNED CITIZENS OF HONOLULU'S CONTENTIONS RE: STAFF SAFETY REVIEW

Under penalty of perjury, I, Dr. George Pararas-Carayannis, hereby declare that:

1. I have a Ph.D. in Marine Sciences from the University of Delaware, a M.S. in Oceanography from the University of Hawai'i, and both a B.S. in Chemistry-Mathematics and an M.S. in Chemistry from Roosevelt University. I have considerable experience in mathematical modeling and field studies of natural disasters, environmental engineering, coastal engineering, geology, seismology, volcanology, geophysics, risk analysis, disaster planning/mitigation, real time data systems, and hazard reduction.

2. I previously filed declarations in support of Concerned Citizens of Honolulu's Contentions Re: Draft Environmental Assessment And Draft Topical Report. My credentials to discuss the potential effects of natural phenomena and other technical issues related to Pa'ina Hawaii, LLC's proposed irradiator were stated in my prior declarations and will not be repeated here.

3. I have reviewed Pa'ina Hawaii, LLC's materials license application and related documents on file in this proceeding, including the Nuclear Regulatory

Commission Staff's August 17, 2007 Safety Evaluation Report ("SER") (ADAMS Accession No. ML072260186).

4. Based on my review of documents related to the proposed irradiator, I prepared an independent assessment of the natural hazard risk to the facility at the Palekona Street site Pa'ina has selected. A true and correct copy of my report, entitled "Assessment of Natural Disaster Risks for the Proposed Site of Pa'ina Hawaii, LLC's Cobalt-60 Irradiator Facility At 192 Palekona Street, Honolulu, Hawai'i," is attached hereto as Exhibit "5" and incorporated herein by reference.

5. For the reasons discussed in my report, my opinion is that hurricanes, tsunamis, and earthquakes involving the proposed irradiator may have significant impacts that merit much more rigorous review than the Staff had performed. Unfortunately, the SER reveals the Staff still has failed to perform the additional review needed to ensure Pa'ina satisfies all applicable safety requirements, including 10 C.F.R. § 30.33(a)(2)'s requirement that Pa'ina establish its proposed irradiator would be "adequate to protect health and minimize danger to life or property." The SER contains no analysis whatsoever of potential safety risks related to tsunamis and hurricanes, to which the site is particularly susceptible due to its location adjacent to Ke'ehi Lagoon and within the tsunami evacuation zone. Moreover, as discussed below, the SER's cursory discussion of seismic risks is inadequate to ensure against damage from earthquakes.

6. In my report, I noted that Pa'ina proposes to build its irradiator on unconsolidated alluvial sediments (i.e., silty gravel and sand), where liquefaction can occur. In discussing this important safety issue, the SER states merely that "the factor of safety against liquefaction would be in an acceptable range as long as the Standard

Penetration Test (SPT) blowcount from the soil boring was of an adequate value." While this statement is accurate as a general proposition, the SER fails to consider whether, in fact, the SPT blow count is "of an adequate value." Review of Pa'ina's September 14, 2005 geotechnical report (ADAMS Accession No. ML053460276) reveals the recorded blow counts are far from adequate to ensure against damage from liquefaction.

7. The geotechnical report's estimate of maximum allowable bearing values of 1,400 pounds per square foot for foundation resistance appears reasonable under normal (i.e., non-liquefaction) conditions. However, if liquefaction occurs during an earthquake, the bearing resistance will not be the same. There is a fundamental difference between static stability and seismic stability. The bearing values in the geotechnical report refer only to the static stability of the landfill material at Pa'ina's preferred site, not to its seismic stability. Regardless of the safety factor added to the static stability values, the Staff cannot determine whether construction of an irradiator at the site would be safe without a proper seismic stability analysis and discussion of associated risks. This was not done, precluding an informed decision about safety of the proposed irradiator in the event of liquefaction during an earthquake.

8. Most of the damage to even new buildings in downtown Mexico City in the 1985 earthquake occurred because of liquefaction. Downtown Mexico City is the location of an old dry lake underlain by about 30 feet of sediments. Although Mexico City was about 300 km away from the earthquake epicenter, a focused monochromatic seismic surface wave that reached the 30-foot sediment layer amplified the seismic accelerations and caused the liquefaction that destroyed high rise buildings at sites where SPTs had been performed and foundation resistance tests had been considered adequate.

The same type of liquefaction destroyed buildings and highway overpasses in San Fernando Valley in California when the moderate 1994 Northridge earthquake struck. All buildings and structures that were destroyed had been built in accordance to earthquake building codes (revised and upgraded after the 1971 San Fernando earthquake) and at sites that prior engineering studies and SPT's had considered "safe."

9. The site Pa'ina has proposed for its irradiator is on reclaimed land that has been filled with non-homogeneous, unconsolidated alluvial material, most of which was dredged from the existing waterway of Ke'ehi Lagoon. The density of material, the granular composition, silt content, and the particle size distribution vary, as well as the degree of settling. This is why the blow count values presented in the geotechnical report vary so much, with values ranging from 4 to 120.

10. Many of the geotechnical report's blow count values were below 15, indicating a substantial risk of liquefaction from an earthquake. Indeed, with such low blow counts, an earthquake would not have to be particularly significant to cause liquefaction. Depending on the epicenter, depth and directional focusing, even a relatively small event could result in liquefaction, presenting significant safety concerns since, in addition to the low blow count values, the site has groundwater only a few feet below the surface. The material below the Pa'ina site (silty sands and gravel) is supersaturated with water, and there could be at least partial – if not total – liquefaction at the toe of any structure built on such a site. Consequently, the SER's apparent assumption that the blow counts at the site are "of an adequate value" to ensure against liquefaction lacks any basis.

11. The SER's conclusion that the six-inch separation between the sides of the irradiator pool and the building slab "should provide adequate isolation" in the event of an earthquake is similarly unsubstantiated. The SER bases this finding on inaccurate assumptions about what constitutes "a seismic event typical of the area." As explained in my report, the Staff has improperly trivialized the potential intensity of ground motions at the proposed irradiator site, inaccurately assuming that the Modified Mercalli Intensity V estimated for the island of O'ahu for the October 2006 earthquake is the maximum earthquake ground force that can be expected at the proposed site. The Lana'i earthquake of 1871, the Maui earthquake of 1938, and the 1948 earthquake offshore of Honolulu all produced greater than Force V Intensities, with the 1871 event reported to have caused damage to every building at the Punahou School Campus.

12. Unlike magnitude, which represents a single quantity of an earthquake's energy release, intensity does not have one single value for a given earthquake. Rather, it can vary significantly from place to place depending on substrata soil conditions. There is no evidence the Modified Mercalli Intensity estimate on which the Staff relied took into account the properties of unconsolidated sediments like those found at the irradiator site. Similarly, the potential horizontal seismic ground motions on which the Staff relied represent statistical estimates for the southern coast of O'ahu which may not be valid for the alluvial material at the proposed facility site. In addition, the Staff failed to consider the potential focusing effects of seismic energy on O'ahu. Due to the flaws in the underlying analysis, there is, accordingly, no basis for the SER's assumption about what constitutes "a seismic event typical of the area," casting serious doubt on its conclusion the irradiator design would provide "adequate isolation" in the event of an earthquake.

13. Without a proper soil analysis and plasticity study, the Staff has no scientifically defensible basis to conclude the site is safe from liquefaction. Borings alone, cone penetration tests or blow counts – even when closely spaced – are not sufficient. If anything, blow counts of such diversity as those presented in the geotechnical report indicate highly non-homogeneous and potentially unsafe soil conditions that may be particularly susceptible to liquefaction. Due to the variability and uncertainty of the data in the geotechnical report, the Staff's interpretation is erroneous and provides a misleading assessment of the liquefaction hazard at Pa'ina's preferred site.

14. In my opinion, additional analysis is needed to assess whether the proposed irradiator would be safe in the event of an earthquake, including whether the factor of safety against liquefaction is in an acceptable range. Either the Staff or Pa'ina must perform this analysis, as well as a thorough review of safety risks associated with tsunamis and hurricanes, before one could make an informed decision about whether Pa'ina's proposed irradiator would be "adequate to protect health and minimize danger to life or property," as 10 C.F.R. § 30.33(a)(2) requires.

I declare under penalty of perjury that the factual information provided above is true and correct to the best of my knowledge and belief, and that the professional opinions expressed above are based on my best professional judgment.

Executed at Honolulu, Hawai'i on this 12th day of September, 2007.

Dr. George Pararas-Carayannis

David Henkin

From: Michael Clark [MJC1@nrc.gov]
Sent: Tuesday, August 21, 2007 5:20 AM
To: David Henkin; Fred Benco
Cc: Margaret Bupp
Subject: Safety Evaluation Report for Pa'ina Irradiator

Attachments: ML0722601860.pdf

ML0722601860.pdf
(83 KB)

Attached please find the NRC Staff's final Safety Evaluation Report related to Pa'ina's application for an underwater irradiator license.
This document will also be publicly available in ADAMS (ML072260186), with a release date of August 23, 2007.

Please contact me if you have any questions or need additional information.

Michael Clark
U.S. Nuclear Regulatory Commission
Office of the General Counsel
11555 Rockville Pike
Mail Stop: O15D21
Rockville, MD 20852-2738

301-415-2011 (ph.)
301-415-3725 (fax)

EXHIBIT 1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Pa'ina Hawaii, LLC Materials License Application	)))))	Docket No. 30-36974-ML ASLBP No. 06-843-01-ML

DECLARATION OF MARVIN RESNIKOFF, Ph.D. IN SUPPORT OF CONCERNED CITIZENS' CONTENTIONS RE: DRAFT ENVIRONMENTAL ASSESSMENT AND DRAFT TOPICAL REPORT

Under penalty of perjury, I, Dr. Marvin Resnikoff, hereby declare that:

1. I am a physicist with a Ph.D. in high-energy theoretical physics from the University of Michigan and also the Senior Associate of Radioactive Waste Management Associates ("RWMA"), a private technical consulting firm based in New York City. I previously filed declarations in support of Concerned Citizens of Honolulu's Request for Hearing. My credentials to discuss technical issues related to Pa'ina Hawaii, LLC's proposed irradiator were previously stated in my prior declarations and will not be repeated here.

2. I have reviewed the Draft Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawaii ("Draft EA") (ADAMS Accession No. ML063470231), the Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Pa'ina Hawaii, LLC Irradiator Facility ("Draft Topical Report") (ADAMS Accession No. ML063560344), and other documents from the hearing file.

EXHIBIT 2

3. As described in greater detail below, in my opinion, the Draft Topical Report significantly underestimates the probability of an aircraft impacting Pa'ina's proposed irradiator and fails to provide any meaningful analysis of the potential consequences of an aviation accident, which could pose significant threats to public health and safety.

4. In addition, the Draft Topical Report inaccurately assumes the irradiator's cobalt-60 ("Co-60") sources would remain shielded in the event of an aviation accident or natural disaster that breaches the irradiator pool, allowing the water which serves as passive shielding to leak out. The Draft Topical Report ignores that the depth of the water table is two meters (6.6 feet) below the irradiator floor, which marks the lowest water level required to retain shielding integrity. Accordingly, any accident that allows the water level in the pool to fall below the floor level would severely reduce shielding, threatening radiation exposure. The Draft Topical Report fails, however, to examine such threats.

5. Because of the Draft Topical Report's many flaws, Pa'ina cannot rely on it to establish that its proposed irradiator design would be adequate "to protect health and minimize danger to life or property," as required by 10 C.F.R. § 30.33(a)(2).

6. Because the Draft EA relies on the Draft Topical Report's flawed analysis, its discussion of potential environmental impacts associated with Pa'ina's proposed irradiator is likewise lacking, failing to take into consideration potentially significant impacts to public health and safety and to the environment from aviation accidents and natural disasters. The Draft EA also fails to analyze potentially significant impacts associated with terrorist attacks on the irradiator or on Co-60 sources being transported to

or from the irradiator and does not consider transportation accidents involving such sources.

7. Since the reason for the high probability of an aircraft impact is the proximity of the proposed facility to active runways at Honolulu International Airport ("HNL"), the Draft EA should have evaluated alternate locations for the irradiator, far from the airport, which would substantially reduce risks to the public associated with aviation accidents.

8. Overall, the Draft EA fails to take a hard look at the potential impacts associated with Pa'ina's proposal to operate a nuclear irradiator adjacent to active runways at HNL and does not consider reasonable alternatives that would accomplish the project's goals with less environmental harm.

9. **Probability of Aircraft Impact into Proposed Pa'ina Irradiator.** Using the Department of Energy ("DOE") standard, DOE-STD-3014-96, "Accident Analysis for Aircraft Crash into Hazardous Facilities," I calculated the expected accident frequency (i.e., the number of accidents per year) of an aircraft impacting the proposed Pa'ina Hawaii irradiator. The DOE standard is similar to the Nuclear Regulatory Commission ("NRC") methodology (NUREG-0800) I employed in the NRC proceedings regarding the proposed PFS spent fuel storage facility at Skull Valley, Utah. Since NUREG-0800 is designed primarily for potential facilities located at some distance from an airport, not for facilities like the Pa'ina irradiator which would be immediately adjacent to active airport runways, I question the Center for Nuclear Waste Regulatory Analyses's ("CNRWA's") decision to rely solely on NUREG-0800 for the Draft Topical Report's analysis.

10. My report, a true and correct copy of which is attached hereto as Exhibit "1" and is incorporated herein by reference, details the methodology and calculations I employed to determine the probability of an aircraft impact into the proposed irradiator. In summary, I concluded that the yearly probability using DOE's national crash statistics would be 3.59E-04 (1 in 2,786). If HNL-specific crash rates are used, the yearly probability increases to 5.69E-04 (1 in 1,757).

11. Both crash rates are significantly higher than the yearly probability set forth in CNWRA's Draft Topical Report, 2.0E-04 (1 in 5,000). There are many reasons for the Draft Topical Report's substantial understatement of the risk of an airplane striking the proposed Pa'ina irradiator. First, CNWRA relies on airplane crash data that are more than thirty years old and not applicable to all aircraft. In contrast, the DOE data I used are applicable to all aircraft, including air taxis (which currently constitute over 20% of aircraft operations at HNL), and are updated to 1996. In addition, the Draft Topical Report fails to account for the fact that air crash rates for HNL are higher than the national average, as I did in my alternate calculations using HNL-specific crash rates.

12. Second, the methodology CNWRA used for the Draft Topical Report looks solely at the distance a proposed facility is from the end of the runway, failing to take into account that landings have a higher crash rate than takeoffs.

13. Third, the methodology CNWRA used for the Draft Topical Report employs an equal probability of an air crash to all locations in the vicinity of an airport, and this is not correct. To take one example, for military aircraft, planes fly parallel to the runway, then make a U-turn and land. The side where military planes first fly is

called the "pattern" side. Accordingly, my analysis assumed that the pattern side is over the ocean. This type of fine detail is missing from the Draft Topical Report's analysis.

14. Fifth, the number of aircraft operations at HNL used in the Draft Topical Report's calculations understates the actual number of current operations, and also fails to account for anticipated future growth during the time period for which Pa'ina seeks a materials license. Although unstated in the report's analysis, it appears CNWRA used the average number of aircraft operations at HNL over the past five years, which would reflect the substantial decrease in the number of operations at HNL following September 11, 2001. Since the number of operations at HNL did not begin to increase until the last couple of years and, as the Draft Topical Report concedes, is expected to increase by another 20% during the 10-year period of Pa'ina's license application, the number of operations CNWRA uses in its calculations is unrealistically low. A more realistic, but still conservative, assumption is to use current operational levels. My analysis took this approach, using the most recent numbers available, which are from airport operations in 2005.

15. **Consequences of Aircraft Impact into Pa'ina Irradiator.** Whether the Board accepts the Draft Topical Report's crash rate or those presented in my report, the aviation impact frequency exceeds by two orders of magnitude the one in a million per year threshold that ordinarily triggers the requirement to evaluate the consequences of an airplane crash (i.e., the likelihood that, in the event of an airplane crash, radiation releases would occur). The Draft Topical Report fails, however, to take into account realistic accident scenarios and does not provide any data or calculations to demonstrate the

design of Pa'ina's proposed irradiator would be adequate "to protect health and minimize danger to life or property," as required by 10 C.F.R. § 30.33(a)(2).

16. While the Draft Topical Report asserts that Co-60 sources that can satisfy the tests set forth in 10 C.F.R. § 36.21 would be robust enough to survive an aviation accident, CNWRA never performs any calculations to back up that claim. For example, it does not quantify the impact of flying airplane debris following a collision to allow a comparison with the impact associated with a 2.5 cm-diameter, 2-kg steel weight dropped from a height of 1 meter, the standard set forth in 10 C.F.R. § 36.21(d). It is not intuitive that an exploding airplane would exert no more force on the irradiator's sources than a weight falling from the height of a tabletop. Likewise, the Draft Topical Report fails to assess the extreme temperatures that would be associated with burning tens of thousands of pounds of jet fuel, which could far exceed the 600 °C for 1 hour standard in 10 C.F.R. § 36.21(b). In the absence of calculations, there is no basis for the Draft Topical Report's assumption an airplane crash would not breach the sources, creating the potential for radiation releases.

17. Damage to the irradiator pool due to an air crash (such as from the shaft of a jet plane striking the pool) may damage the pool structure under the floor level, such as tears of the welds and consequent loss of irradiator pool shielding water. Since the floor level is also the minimum water level necessary to retain shielding integrity for the Co-60 sources, such a breach of the pool structure would reduce the irradiator's passive shielding. The Draft Topical Report assumes the depth of the water table is 2 meters (6.6 feet) below the facility floor, and, thus, its assertion that sea water infiltrating through a breach would adequately shield the Co-60 sources is unsupported. In fact, any break in

the pool lining below the floor level – whether from an aviation accident or natural disaster – could dangerously reduce the shielding of the sources.

18. The Draft Topical Report ignores the potential for contamination of the pool water in the event that an airplane crash breaches the sources. If the aviation accident also ruptured the pool lining, water contaminated with radioactive cobalt could escape the facility, contaminating groundwater and nearby Ke'ehi Lagoon.

19. The force of the impact from an air crash into the facility and/or the ensuing fire and explosion of aviation fuel will likely lead to loss of all monitoring equipment, loss of the structure itself, loss of irradiator shielding, and the loss of all personnel (and consequent inability to implement necessary emergency procedures). The Draft Topical Report fails to analyze any of the potential consequences discussed above, any of which would pose significant threats to public health and safety. Since the Draft EA relies on the Draft Topical Report for analysis of these potential impacts, its discussion is similarly deficient.

20. **Terrorist Attacks on Irradiator.** The Draft EA improperly fails to analyze potential threats to the public and the environment associated with Pa'ina's proposal to place a major sabotage target in the middle of urban O'ahu. As recognized by the National Nuclear Security Administration, Co-60 is an attractive target for terrorists because it can be used to make dirty bombs. See April 13, 2005 press release from the National Nuclear Security Administration, a true and correct copy of which is attached hereto as Exhibit "2." It is also well-known that, in general, nuclear facilities are potential targets of the Al Qaeda organization. If Co-60 were stolen from the proposed facility and then used in a dirty bomb, or if the facility were directly attacked, Co-60

could be released into the environment, causing adverse health effects and spreading contamination.

21. Pa'ina seeks a license to store up to a million curies of Co-60 at its irradiator. The Federation of American Scientists ("FAS") has analyzed the effect of a terrorist incident involving a much smaller quantity of Co-60, only 17,000 curies. See Public Interest Report, vol. 58, No. 2, March/April 2002, a true and correct copy of which is attached hereto as Exhibit "3." The FAS report estimates that, if a single Co-60 "pencil" were dispersed by an explosion at the lower tip of Manhattan, an area of approximately one-thousand square kilometers would be contaminated, and tens of thousands of New York City residents could die. Similarly disastrous consequences would occur in Hawai'i in the event of dispersal of Co-60 from Pa'ina's proposed irradiator. The Draft EA fails, however, to analyze these significant impacts.

22. **Terrorist Attacks on Cobalt Sources in Transit.** The Draft EA assumes that Co-60 sources would be shipped to Pa'ina's facility approximately once per year. Such sources, in transit from Canada or Russia to the Pa'ina Hawaii plant, would not be well-protected from a terrorist attack. The NRC does not require armed escorts for Co-60 sources, and potential saboteurs have significant fire power at their disposal. The TOW2 and MILAN anti-tank missiles have a range of one kilometer or more and can penetrate one meter of steel, far more steel and lead than the walls of a shipping cask. The newer Russian Koronet missile, used by former Iraqi armed forces, can penetrate 1.2 meters of steel and can be aimed precisely at a distance up to five kilometers. These weapons have the ability to penetrate a shipping cask and disperse its contents.

23. A Co-60 cask shipment, attacked within a city, could cause major environmental pollution and cancer fatalities. Local residents would clearly have a greater risk than other persons. While shipments could leave Canada or Europe by a number of routes, once they get close to the facility, the route options are decidedly limited. Such an accident would subject the airport passengers and workers and residents of neighboring communities to irreparable harm. In addition to adverse health effects caused by contamination, such an accident would have significant economic impacts, disrupting the major port of entry to the entire state of Hawai'i. The Draft EA fails completely to consider the potential environmental and economic impacts associated with terrorist attacks on Co-60 shipments to the Pa'ina facility.

24. **Transportation Accidents Involving Cobalt Sources.** Even in the absence of terrorist threats, transporting new Co-60 sources to the facility and used sources from the facility each year poses threats to the public and environment that the Draft EA fails completely to consider. The Draft EA states only that "[t]ransportation impacts from normal operations would be small." There is no analysis of the impact should an accident occur.

25. Without constant shipments of Co-60 to and from the facility, the irradiator could not operate. The Draft EA must identify how the sources will be transported to the facility and then examine the likelihood and consequences of accidents involving transportation of the sources.

26. **Alternate Locations for the Irradiator.** The reason for the high probability of an aircraft impact discussed above is the proximity of the proposed facility to active runways at HNL. If the proposed facility were located over ten miles from the

center of the runways, the conditional probability of an aviation accident would decline by a factor of 1,000, placing the yearly probability within the limits the NRC generally deems acceptable for nuclear facilities. The Draft EA fails, however to consider any alternate locations that might substantially reduce risks to the public associated with aviation accidents.

I declare under penalty of perjury that the factual information provided above is true and correct to the best of my knowledge and belief, and that the professional opinions expressed above are based on my best professional judgment.

Executed at New York, New York on this 9th day of February, 2007.

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The Probability of Aircraft Impact into the Proposed Pa'ina Hawaii Irradiator

NRC Docket No. 030-36974

By
M. Resnikoff, Ph.D.

For
Earthjustice

February 7, 2007

This report evaluates the expected accident frequency, the number of accidents per year, of an aircraft impacting the proposed Pa'ina Hawaii food irradiator. No quantitative assessment is made of the consequences of an aircraft impact into the irradiator, though some of the criteria used by the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC), as they are applicable, are discussed.

The methodology follows the DOE standard, DOE-STD-3014-96, "Accident Analysis for Aircraft Crash into Hazardous Facilities."[1] The DOE standard is similar to the NRC methodology employed by the author in the NRC proceedings regarding the proposed PFS spent fuel storage facility at Skull Valley, Utah, and the Atomic Safety and Licensing Board accepted that testimony.[2] Numerous other analysts have employed this standard to analyze aviation risks at DOE nuclear facilities.[3]

Generally, the NRC methodology[4] in NUREG-0800 is used for potential facilities located at some distance from an airport, not for facilities like the Pa'ina irradiator, which would be in close proximity to airport runways. Accordingly, we question the Center for

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[1] Department of Energy, "Accident Analysis for Aircraft Crash into Hazardous Facilities," DOE-STD-3014-96, October 1996, available at http://hss.energy.gov/NuclearSafety/techstds/standard/std3014/std3014.pdf.

[2] State Of Utah's Prefiled Testimony Of Dr. Marvin Resnikoff For Contention Utah K/Confederated Tribes B, Docket No. 72-22-ISFSI, ASLBP No. 97-732-02-ISFSI, February 19, 2002.

[3] DOE-STD-3014-96, p. B-24.

[4] NUREG-0800, NRC Standard Review Plan, Section 3.5.1.6, Aircraft Hazards.

EXHIBIT 3

Nuclear Waste Regulatory Analyses' (CNRWA's) decision to rely solely on NUREG-0800 for its analysis.[5]

We contrast our methodology with that of CNWRA in a section of this report, but many aspects are identical. Similar to the CNWRA analysis, we consider four types of aircraft: commercial air carriers, air taxis, general aviation and military aircraft. The specific aircraft types for commercial air carriers are generic, that is, no distinction is made for major aircraft carriers between a Boeing 727, 737, 747 or 767 aircraft. For military aircraft, as in the CNWRA analysis, we consider only light fighter jets, like the F-16, and ignore large military aircraft. Our calculation of the fly-in and skid-in area of the proposed facility is identical.

If the impact frequency exceeds 1 in a million per year, the NRC has customarily proceeded to the next step, evaluating the consequences of an airplane crash (i.e., the likelihood that, in the event of an airplane crash, radiation releases would occur). CNWRA devotes only a single paragraph to this important analysis and, without presenting any calculations or other meaningful analysis, simply asserts there are no consequences - end of story. This section of the CNWRA, and of the Environmental Assessment that relies on it, will clearly have to be supplemented to provide a meaningful discussion of the consequences of an aviation accident involving Pa'ina's proposed irradiator.

In the next section we discuss the methodology and the selected data. We also contrast our methodology and data with those of CNWRA. In the following section, we discuss the results of our analysis and recommendations.

Methodology

Aircraft crash frequencies are estimated with a formula that takes into account (1) the number of operations, (2) the probability that an aircraft will crash, (3) given a crash, the probability that the aircraft will crash into a 1-square mile area where the facility is located (the conditional probability), and (4) the size of the facility.[6] In the PFS proceeding[7], we evaluated non-airport activities, that is, the number of crashes per square mile per year expected to occur for Air Force fighter jets during the flight phase. In

[5] Durham, J, *et al*, "Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Proposed Pa'ina Hawaii, LLC, Irradiator Facility," Center for Nuclear Waste Regulatory Analyses, December 2006.

[6] DOE-STD-3014-96, p. 38.

[7] Ref. 2 above

contrast, for Pa'ina's proposed facility, we take into account only takeoffs and landings, using a combination of Honolulu International Airport (HNL) specific information and generic information. A second calculation we perform employs the default assumptions of DOE's standard, DOE-STD-3014-96.

Mathematically the formula that is employed is the following:

$$F = \sum_{i,j,k} N_{ijk} P_{ijk} f_{ijk}(x,y) A_{ij} \qquad (1)$$

where:

F =	estimated annual aircraft crash impact frequency into the proposed irradiator (no./y),
N_{ijk} =	estimated annual number of takeoffs and landings for each aircraft category and each runway,
P_{ijk} =	aircraft crash rate per take-off and landing for HNL or generically for the U.S.
$f_{ijk}(x,y)$ =	crash location conditional probability – given a crash, the likelihood it will be into the facility,
A_{ij} =	the effective area of the facility that includes skid-in and fly-in effective areas for each aircraft, for takeoffs and landings,
i =	index for flight phase, i = 1,2,3 for take-off, in-flight and landing (for purposes of this analysis, we ignore in-flight crashes),
j =	index for aircraft category (Air Carrier Operations, Air Taxi Operations, General Aviation Operations, and Military Operations),
k =	flight source (4 runways).

We next evaluate each of the parameters in Equation (1).

Number of Operations

We first estimate the number of aircraft operations N_{ijk}, that is, the total takeoffs and landings at the Honolulu International Airport, by averaging the historical data. The data for each type of aircraft operation at HNL appear in Table 1; the data are provided by the Federal Aviation Administration (FAA). Over a 30-year period of time, the average number of aircraft operations at HNL, according to the FAA, is 356,772 per year.[8] For

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[8] http://www.apo.data.faa.gov, "APO Terminal Area Forecast Summary Report, HNL"

2005, the number of air craft operations, according to the FAA, was 334,660.[9] Hawaii DOT says the number of aircraft operations in 2005 was 330,506.[10] The number of aircraft operations at HNL declined following September 11th, but increased in 2005. As noted in the CNWRA analysis, the FAA expects the number of persons visiting Hawaii and the number of aircraft operations at HNL to continue to increase, with an increase to 510,000 operations by fiscal year 2012. However, this potential increase is not factored into CNWRA's probability calculations, nor ours.

The accident rates at HNL for each aircraft category, except for military aircraft (for which HNL-specific accident rates were not available) appear in Tables 2 through 4.[11] The average number of accidents per year at HNL, averaged over all non-military aircraft, is 2.633; the average number of fatal accidents per year, averaged over all non-military aircraft, is 0.5. Expressed in terms of the average number of accidents per 100,000 takeoff and landings (excluding military aircraft), the number is 0.80; the average number of fatal accidents per 100,000 takeoff and landings of non-military aircraft at HNL is 0.153.

The NTSB defines a crash as "any aircraft accident that results in destruction or substantial damage to the aircraft."[12] A crash is therefore not necessarily an accident involving fatalities, but for this analysis, we equate a fatal accident with a crash. Further, we sum up all fatal accidents for all aircraft types to get an HNL-specific fatal accident rate. Also we carry out a separate analysis employing the crash rates for individual aircraft, as developed by the DOE.[13] The contrasting crash rates are presented in Table 6.

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[9] *Ibid.* In contrast, CNWRA claims the FAA has recorded 323,726 aircraft operations for the year 2005. Since both CNWRA and RWMA state they are using data from the FAA, the discrepancy between the two figures will have to be resolved.
[10] Schlapak, B, email to M Blevins, NRC, 10/31/2006.
[11] Table 5 sets forth the annual number of departures and landings of military aircraft.
[12] DOE-STD-3014-96
[13] *Ibid.*

Table 1. Departures and Landings for Honolulu International Airport, 1975-2005[a]

Year	Aircraft Operations	All Accidents	Fatal Accidents	Incidents	Acc/100,000 Dep + Land	Facc/100,000 Dep+Land
2005	318853	1	0	0	0.314	0.000
2004	290737	2	0	0	0.688	0.000
2003	294631	0	0	1	0.000	0.000
2002	300111	1	0	0	0.333	0.000
2001	323522	1	0	2	0.309	0.000
2000	326698	1	0	1	0.306	0.000
1999	323922	2	0	0	0.617	0.000
1998	312596	0	0	2	0.000	0.000
1997	340742	3	0	0	0.880	0.000
1996	351065	3	0	0	0.855	0.000
1995	352814	4	1	0	1.134	0.283
1994	335532	2	1	1	0.596	0.298
1993	341316	2	2	0	0.586	0.586
1992	381879	3	2	0	0.786	0.524
1991	369856	3	0	0	0.811	0.000
1990	368827	0	0	0	0.000	0.000
1989	362644	4	1	0	1.103	0.276
1988	331229	2	0	1	0.604	0.000
1987	365111	6	1	0	1.643	0.274
1986	334884	2	0	0	0.597	0.000
1985	323598	2	0	0	0.618	0.000
1984	312492	3	0	0	0.960	0.000
1983	297071	2	0	0	0.673	0.000
1982	278589	2	0	1	0.718	0.000
1981	320079	2	1	2	0.625	0.312
1980	352856	5	1	0	1.417	0.283
1979	379488	4	0	0	1.054	0.000
1978	329969	3	0	2	0.909	0.000
1977	296869	9	3	1	3.032	1.011
1976	274714	5	2	0	1.820	0.728
1975		5				
	329756.5	**2.633**	**0.500**	**average =**	**0.800**	**0.153**

a In this table, military operations at HNL are excluded in determining total operations and accident and fatal accident rates.

Table 2. Departures and Landings (HNL) Air Carrier

Year	Air Carrier Operations	All Accidents	Acc/100,000 Dep + Lnd
2005	184937		0
2004	166121		0.000
2003	167562	1	0.597
2002	174544		0.000
2001	196351	2	1.019
2000	206786	1	0.484
1999	192137	1	0.520
1998	183856	2	1.088
1997	186648	2	1.072
1996	205600	2	0.973
1995	199801	1	0.500
1994	191176	1	0.523
1993	187950		0.000
1992	201999		0.000
1991	194293		0.000
1990	194000		0.000
1989	195981	1	0.510
1988	187445	1	0.533
1987	214028	1	0.467
1986	184523	1	0.542
1985	163562		0.000
1984	150273	1	0.665
1983	137420	1	0.728
1982	126981	1	0.788
1981	123148	2	1.624
1980	125185		0.000
1979	132696	1	0.754
1978	117663	2	1.700
1977	112111	3	2.676
1976	106447	2	1.879

Table 3. Departures and Landings (HNL) Air Taxis

Year	Air Taxi Operations	All Accidents	Acc/100,000 Dep + Lnd
2005	65843		0.000
2004	51030		0.000
2003	46433		0.000
2002	44742	1	2.235
2001	35037		0.000
2000	30402		0.000
1999	38675		0.000
1998	42195		0.000
1997	68423	1	1.461
1996	60536		0.000
1995	70245		0.000
1994	55425		0.000
1993	55216		0.000
1992	59984		0.000
1991	63608	1	1.572
1990	56909		0.000
1989	67022		0.000
1988	57366	1	1.743
1987	65993		0.000
1986	71823		0.000
1985	78638		0.000
1984	75101	1	1.332
1983	74530		0.000
1982	69106	1	1.447
1981	75354		0.000
1980	77632	2	2.576
1979	87131	1	1.148
1978	81108		0.000
1977	66783	1	1.497
1976	53896		0.000

Table 4. Departures and Landings (HNL) General Aviation

Year	General Aviation Operations	All Accidents	Acc/100,000 Dep + Lnd
2005	68073	1	1.469
2004	73586	2	2.718
2003	80636		0.000
2002	80825		0.000
2001	92134	1	1.085
2000	89510	1	1.117
1999	93110	1	1.074
1998	86545		0.000
1997	85671		0.000
1996	84929	2	2.355
1995	82768	3	3.625
1994	88931	2	2.249
1993	98150	2	2.038
1992	119896	3	2.502
1991	111955	2	1.786
1990	117918		0.000
1989	99641	3	3.011
1988	86418	1	1.157
1987	85090	4	4.701
1986	78538	1	1.273
1985	81398	2	2.457
1984	87118	1	1.148
1983	85121	1	1.175
1982	82502	1	1.212
1981	121577	2	1.645
1980	150039	3	1.999
1979	159661	2	1.253
1978	131198	3	2.287
1977	117975	6	5.086
1976	114371	3	2.623

Table 5. Departures and Landings (HNL) Military[a]

Year	Military Operations	All Accidents	Acc/100,000 Dep + Lnd
2005	15807		
2004	16847		
2003	15884		
2002	15978		
2001	16465		
2000	16598		
1999	21080		
1998	21685		
1997	23991		
1996	23900		
1995	23410		
1994	21584		
1993	23879		
1992	31846		
1991	23853		
1990	37998		
1989	43466		
1988	35912		
1987	23924		
1986	29011		
1985	30293		
1984	30938		
1983	29669		
1982	27403		
1981	31813		
1980	32607		
1979	31888		
1978	35564		
1977	33704		
1976	43473		

[a] In our calculations for crash rates we use the data from DOE-STD-3014-96.

From Tables 2,3 and 4, we see that the average number of accidents for air carriers, air taxis and general aviation is, respectively, 0.655, 0.5 and 1.768 per 100,000 takeoffs and landings. The accident rate for military aircraft was not provided by the Hawai'i Department of Transportation, so we employed the average crash rate for small military aircraft for the entire U.S., 0.18 and 0.33 crashes per 100,000 takeoffs and landings, respectively.[14] For all of the above aircraft categories, for the RWMA calculations, we averaged the accidents due to takeoffs and due to landings at HNL, assuming the number of takeoffs equal the number of landings. Table 6 compares our results to those of DOE.

Table 6. Aircraft Accident Rates

Aircraft	DOE Crash Rate Takeoff per 100,000	DOE Crash Rate Landing per 100,000	RWMA HNL Takeoff, Landing per 100,000
General Aviation[1]	0.35	0.83	0.153
Air Carrier	0.019	0.028	0.153
Air Taxi	0.1	0.23	0.153
Military[2]	0.18	0.33	0.18/0.33

Notes:
[1] Fixed wing turboprop
[2] Small military aircraft includes fighter jets, attack aircraft and trainers

The data for the DOE crash rates are taken from an NTSB data base, for the country as a whole.[15] As expected, the crash rate for landings is greater than the crash rate for takeoffs. The RWMA crash rate combines takeoffs and landings (except for military aircraft), but is specific to HNL. Except for air carriers, DOE's accident rate for all aircraft is generally greater than RWMA's, but this is somewhat misleading, since air carriers comprise over half the takeoffs and landings at HNL. Weighted by the number of aircraft operations for each aircraft, DOE's average crash rate is actually smaller than RWMA's, reflecting a higher than average crash rate at HNL.

The crash rate used in the CNWRA analysis is not directly comparable to the rates listed in Table 6, since CNWRA combines the overall crash rate with a type of conditional probability, as discussed further below. But it is important to note that the CNWRA

[14] FAA data, footnote 8.
[15] DOE-STD-3014-96

crash rate does not distinguish between takeoffs and landings, and this is clearly incorrect. Further, conditional probability analysis takes into account the spatial distribution of accidents, which will differ depending on whether a takeoff or landing is involved. In contrast, RWMA's analysis considers takeoffs and landings, as well as the specific aircraft involved, in calculating the conditional probabilities.

Conditional Probabilities

Given an air crash, we next have to determine the likelihood that the proposed irradiator would be hit within a square mile area; this is called the conditional probability, $f_{ijk}(x,y)$. These conditional probabilities come from NTSB national averages and appear in the DOE report,[16] updated to 1996. Essentially, from a large database listing locations of crashes near airports, NTSB has determined, for each type of aircraft, the probability of an air crash with distance from the center of a runway. To utilize the database, one must determine the location of the proposed facility with respect to the center of each runway. A Cartesian coordinate system must be set up. See Figure1 below. The origin is the center of each runway.

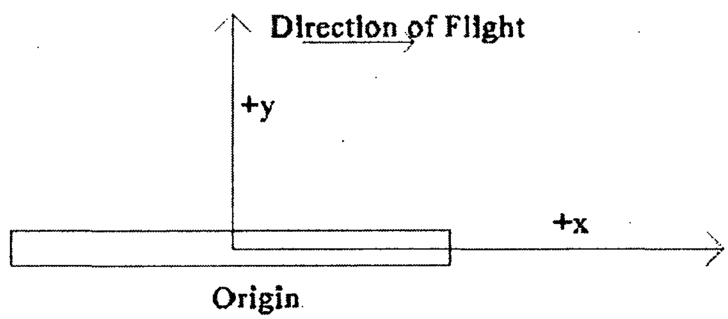

Figure 1. Coordinate convention for use with crash location probability tables for commercial and general aviation

The conditional probabilities for military aircraft are more complicated, but since the basic information is presently not available to us, we have had to simplify the data. Military aircraft land by first approaching parallel to the runway, turning 180 degrees and then landing. See Figure 2. For this reason, the side of the runway the military aircraft approaches before its base leg turn (called the pattern side), has a higher probability distribution. However, since we do not have information regarding military aircraft

[16] DOE-STD-3014-96, Appendix B.

landings at HNL, we have assumed that the pattern side is over the ocean. For military aircraft, there is no pattern side for takeoffs.

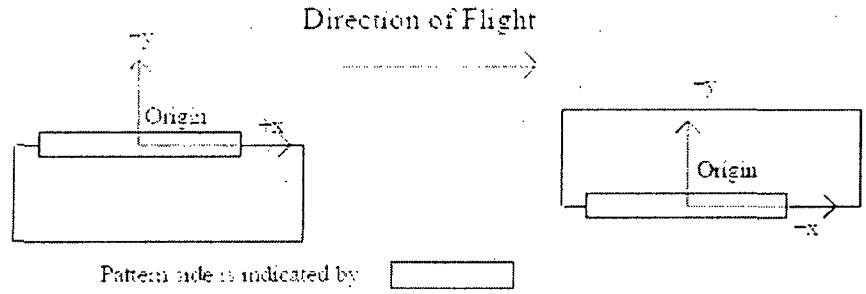

Figure 2. Coordinate convention and pattern side, for use with crash location probability tables for military aviation.

The conditional probabilities specify, given an air crash, the likelihood the accident will take place at a specific location. We therefore have to place the proposed irradiator facility in its relation to each of the four runways at Honolulu International Airport. The locations of the runways at HNL and of the proposed Pa'ina Hawaii irradiator are shown in Figure 3.

As seen in Fig. 3, the proposed facility is located extremely close to and lies between the runways (4R,22L) and (8R,26L), the reef runway. It is approximately ¼ mile from each runway and a little more than ½ mile from the major runway (8L,26R). Table 7 lists the distances of the proposed facility from the center of each of the four runways. The conditional probability distributions are probability estimates in one square mile blocks. That is, given a crash, the conditional probabilities provide the probability that the crash takes place in an area of one square mile. As seen in Table 7, the centers of all runways are within one mile of the proposed facility.

Effective Area Calculations

Employing the conditional probabilities developed by DOE from the NTSB database, we now have three parts of the probability calculation – the number of flights of each type aircraft, the probability of a crash per 100,000 takeoff and landings, and the conditional probability, if a crash takes place, that it will occur within a specific 1-square mile area. The final piece is to calculate the effective area of the facility such that if an unobstructed aircraft were to crash within the area, it would impact the facility, either by direct fly-in or by skidding into the facility. The effective area depends on the dimensions of the

Table 7. (X,Y) Coordinates of Facility with Respect to Center of Each HNL Runway[a]

	8R	**26L**
Landing coordinates	(-1.13,0)	(-1.13,0)
Facility coordinates	(0.47,0.43)	(-0.47,-0.43)
Distance from Runway Center	0.62 mi	0.62mi
	8L	**26R**
Landing coordinates	(-1.17,0)	(-1.17,0)
Facility coordinates	(0.3,-0.81)	(-0.3,0.81)
Distance from Runway Center	0.86 mi	0.86 mi
	4R	**22L**
Landing coordinates	(-0.84,0)	(-0.84,0)
Facility coordinates	(-0.28,0.55)	(0.28,-0.55)
Distance from Runway Center	0.60 mi	0.60
	4L	**22R**
Landing coordinates	(-0.65,0)	(-0.65,0)
Facility coordinates	(-0.36,0.73)	(0.36,-0.73)
Distance from Runway Center	0.81 mi	0.81 mi

Notes:
a. The center of each runway is located at (0,0).

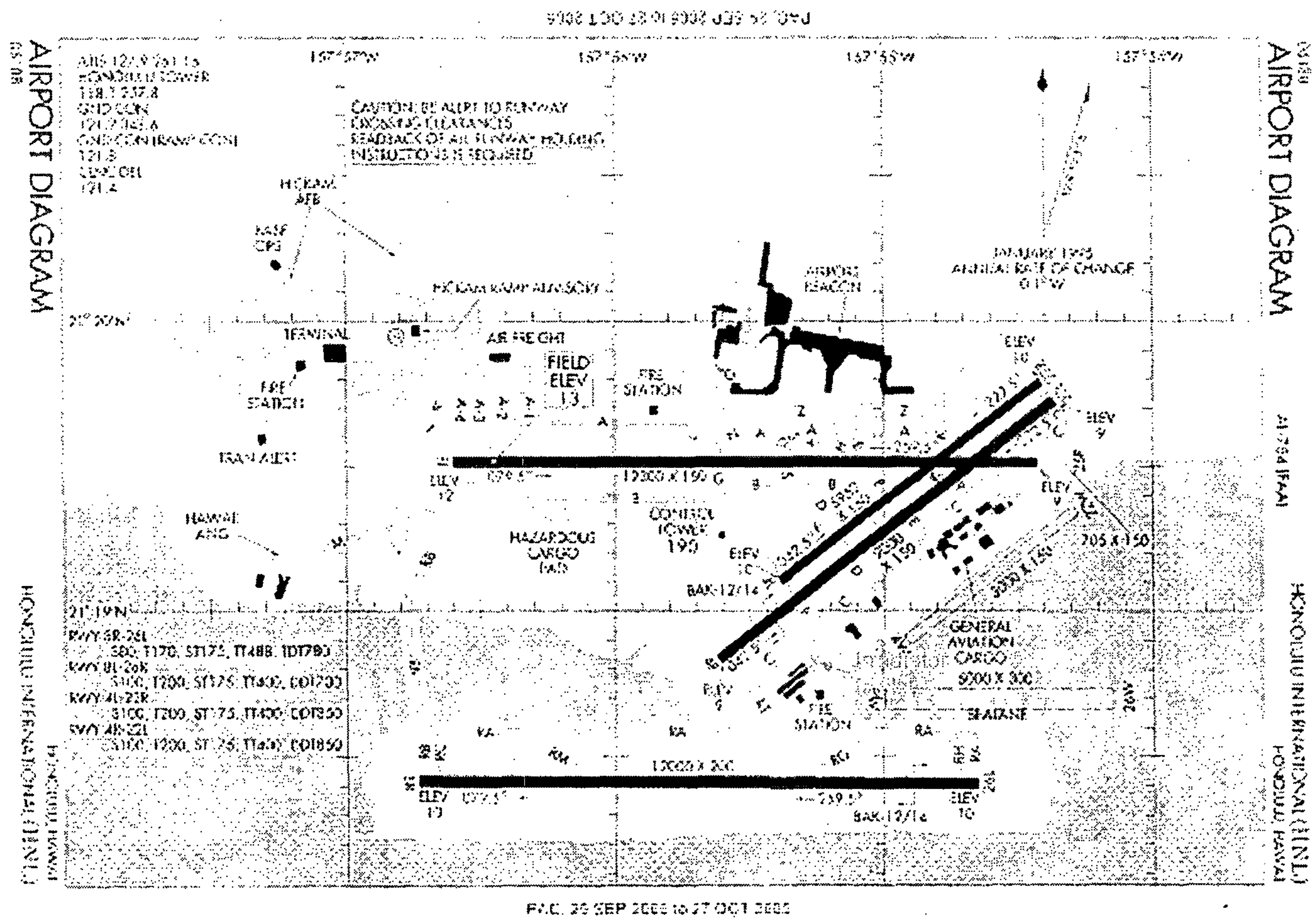

Figure 3. Airport Diagram Honolulu International Airport

proposed facility, the aircraft's wingspan and heading, and the length of the skid. The fly-in area is not just the two dimensional footprint of the building, but the shadow area that takes into account the height of the proposed facility. For this calculation, we will provide two effective area estimates, one for the entire building and another for the irradiator itself, which is a smaller area. We believe it is important to examine not only the probability of impacting the irradiator directly, but impacting the building as well. This is because, as the 9/11 attack has shown, air carriers, particularly on takeoff, carry a tremendous amount of fuel and this must be taken into account in any consequence analysis. Further, as the consequence analysis by M. Sozen and C. Hoffmann has shown, an air crash into the proposed facility will likely bring down part of the building.[17]

A general diagram that shows the parameters used in the equations to calculate the effective area is shown below in Figure 5.

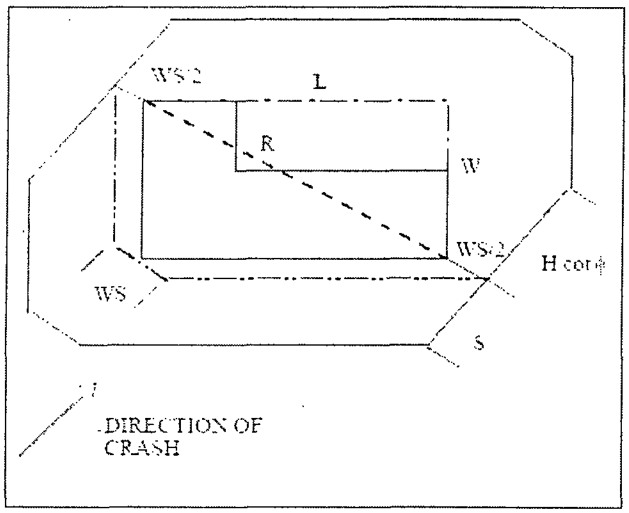

Figure 5. Rectangular facility effective target elements

The effective area of the facility is composed of two elements, the fly-in area A_f and the skid-in area A_s.

$$A_{eff} = A_f + A_s \qquad (2)$$

[17] Sozen, M. and Hoffmann, C., "Analysis of the Effect of Impact by an Aircraft on a Steel Structure Similar to the Proposed Pa'ina Irradiator," January 2007.

As shown in Equation (3), the effective skid-in area is the length of the diagonal of the facility R plus the wingspan of the aircraft WS times the skid distance of the aircraft S. The effective skid-in area is aircraft dependent.

$$A_s = (WS + R)*S \qquad (3)$$

where R is the length of the diagonal of the building or the irradiator, $R = (L^2 + W^2)^{0.5}$. The length L = 64 ft and width W = 116 ft of the proposed irradiator facility[18] and the L = 7.92 ft and width W = 6.75 ft of the irradiator itself[19] are taken from information provided by the applicant. The facility height is 29.6 feet.

Average skid-in areas and wing spans for individual aircraft types are shown in Table 8 below.

Table 8. Skid-In Area (sq mi)

Aircraft	Skid-In Distance (ft)[a]	Wing Span (ft)[a]	Skid-In Area (sq mi) Irradiator Facility	Irradiator
Air Carrier	1440	98	0.01667	0.005599
Air Taxi	1440	59	0.000611	0.000149
General Aviation	73	60	0.000641	0.00018
Military[b]	347	78	0.003763	0.004566

a. From DOE-STD-3014-96, App B
b. Small aircraft – jet fighters, average of take-offs and landings

Note that the skid-in distance and skid-in area for the major air carriers are much greater than for the other aircraft since it is difficult to stop a large, heavy aircraft. For small military aircraft we have averaged the takeoff and landing skid-in areas. Since there are far fewer small military aircraft movements at HNL than air carrier movements, this simplification has a small effect on the overall crash likelihood. The CNWRA and RWMA skid-in areas are the same.

[18] Pa'ina email communication (Oct. 23, 2006) (ML063060603).

[19] Paina Hawaii, Application for Material License, June 23, 2005, Fig. 9-F.

The fly-in area is a sum of three elements - the footprint of the building, an additional element due to the wing span, and a shadow area, taking into account the height of the building. The effective fly-in area can be expressed as follows:

$$A_f = (WS + R)*H\cot\Phi + 2*L*W*WS/R + L*W \qquad (4)$$

where $\cot\Phi$ is the mean of the cotangent of the aircraft impact angle, based on accidents investigated by the NTSB and the FAA. Based on the information provided by the applicant, the height of the irradiator facility is 29.6 feet. The same height is used to calculate the fly-in areas for the irradiator itself.

The results from Eq. (4) for the fly-in area appear in Table 9 below. As seen, the fly-in area for major carriers is much smaller than the skid-in area. Note: the fly-in and skid-in areas calculated by CNWRA are the same as employed by RWMA.

Table 9. Fly-In Area (sq mi)

	Fly-In-In Area (sq mi)	
Aircraft	Irradiator Facility	Irradiator
Air Carrier	0.003156	0.001212
Air Taxi	0.002171	0.000628
Genl Aviation	0.002349	0.000628
Military	0.003419	0.000925

Finally, we combine the fly-in and skid-in areas, with the number of crashes for each aircraft, the number of operations for each aircraft, and the conditional probabilities that estimate locational probabilities given a crash, to obtain the yearly probability of a crash into the irradiator facility, using HNL-specific crash rate (RWMA) and DOE crash rate averages, by aircraft, for the entire U.S. These results are presented in Table 10 below. As seen, the air carriers dominate the probability. The crash probability for RWMA crash rate, number/year, is 5.69E-04. Using DOE (i.e., NTSB) national statistics, the crash probability, number per year, is somewhat lower, 3.59E-04, but both rates are significantly higher than that calculated by CNWRA, 2.0E-04.

Table 10. Probability of Aircraft Accident at Irradiator Facility (#/yr)

Aircraft	DOE	RWMA
General Aviation Takeoff	5.87E-05	2.56E-05
General Aviation Landing	1.25E-04	2.30E-05
Air Carrier Takeoff	3.21E-05	2.59E-04
Air Carrier Landing	2.50E-05	1.36E-04
Air Taxi Takeoff	4.99E-05	7.63E-05
Air Taxi Landing	6.04E-05	4.02E-05
Military Aviation Small Aircraft Takeoff	2.90E-06	2.90E-06
Military Aviation Small Aircraft Landing	5.32E-06	5.32E-06
sum =	**3.59E-04**	**5.69E-04**

Critique of the CNWRA Analysis

1) The crash data in NUREG-0800 employed by CNWRA is apparently based on a 1973 paper by Eisenhut.[20] CNWRA thus relies on airplane crash data that are more than thirty years old and not applicable to all aircraft. In contrast, the DOE data we use are applicable to all aircraft, including air taxis, and are updated to 1996. In addition, the CNWRA analysis fails to account for the fact the air crash rates for HNL are higher than the national average.

2) The NRC and CNWRA methodology, in NUREG-0800, is not specific to take-offs and landings. The crash rates shown in Table 2-6, which are taken from NUREG-0800, are functions of the distance from the end of the runway. However, as the NTSB data shows, landings have a higher crash rate than takeoffs, and this is not taken into account in the CNWRA report.

[20] Eisenhut, D.G., "Reactor Siting in the Vicinity of Airfields," Paper presented at the American Nuclear Society Annual Meeting, June 1973.

3) Further, the NRC and CNWRA methodology employs an equal probability of an air crash to all locations in the vicinity of an airport, and this is not correct. To take one example, for military aircraft, planes fly parallel to the runway, then make a U-turn and land. The side where military planes first fly is called the "pattern" side. In the RWMA analysis, we assume that the pattern side is over the ocean. This type of fine detail is missing from NUREG-0800 and the CNWRA analysis.

4) The number of aircraft operations at HNL used in the CNWRA analysis understates the actual number of current operations, and also fails to account for anticipated future growth during the time period for which Pa'ina seeks a materials license. Although unstated in the CNWRA analysis, it appears it used the average number of aircraft operations at HNL over the past five years, which would factor in the substantial decrease in the number of operations at HNL following September 11, 2001. Since the number of operations at HNL did not begin to increase again until 2005 and, as the CNWRA analysis concedes, is expected to increase by another 20% during the 10-year period of Pa'ina's license application, the number of operations CNWRA uses in its calculations is unrealistically low. A more realistic, but still conservative, assumption is to use current operational levels. The RWMA analysis took this approach, using the most recent numbers available, which are from airport operations in 2005.

5) Because of its methodological flaws, CNWRA underestimates the probability an airplane will crash into the proposed Pa'ina irradiator. Instead of the 2E-4 per year probability CNWRA calculated, the probability should be 3.59E-4, if DOE/NTSB data are used. If HNL-specific data are used, the crash probability should be increased to 5.69E-4.

6) The consequence analysis by the NRC and CNWRA fails to provide any data or calculations to support its conclusions and does not take into account realistic accident scenarios. The CNWRA report asserts that sources that can satisfy the tests set forth in 10 C.F.R. § 36.21 would be robust enough to survive an aviation accident, but never performs any calculations to back up that claim. For example, CNWRA never quantifies the impact of flying airplane debris to compare it with the impact associated with a 2.5 cm-diameter, 2-kg steel weight dropped from a height of 1 meter, the standard set forth in 10 C.F.R. § 36.21(d). Nor does CNWRA assess the extreme temperatures that would be associated with burning thousands of pounds of jet fuel, which could far exceed the 600 °C for 1 hour standard in 10 C.F.R. § 36.21(b). The CNWRA's analysis must be quantified to provide meaningful information about the

possible consequences of an aviation accident involving the Pa'ina irradiator.

7) Damage to the irradiator pool due to an air crash (such as from the shaft of a jet plane striking the pool) may damage the pool structure under the floor level, such as tears of the welds and consequent loss of irradiator pool shielding water. Since the floor level is also the minimum water level necessary to shield the Co-60 sources, such a breach of the pool structure would eliminate the irradiator's passive shielding, on which the NRC and CNWRA rely to justify their "no significant impact" conclusion. Since the CNWRA analysis assumes the depth of the water table is 2 meters (6.6 feet) below the facility floor, its assumption that sea water infiltrating through a breach would adequately shield the Co-60 sources is unsupported. It also ignores the potential for contamination of the water in the pool in the event that an airplane crash breaches the sources. If the aviation accident also ruptured the pool lining, water contaminated with radioactive cobalt could escape the facility, contaminating groundwater and nearby Ke'ehi Lagoon. All of these risks need to be, but were not, analyzed by the NRC and CNWRA.

8) The force of the impact from an air crash into the facility and/or the ensuing fire and explosion of aviation fuel will likely lead to loss of all monitoring equipment, loss of the structure itself, loss of irradiator shielding, and the loss of all personnel (and consequent inability to implement necessary emergency procedures). The NRC and CNWRA fail to analyze any of these potential consequences, any of which would pose significant threats to public health and safety.

Conclusions and Recommendations

As seen, using NTSB data and the DOE methodology, which is standard for these calculations, the expected frequency of an aircraft impacting the proposed Pa'ina Hawaii irradiator is quite high (3.59E-4), over 300 times greater than the NRC's guideline, 1 in a million/year crash probability. The applicant and the NRC must therefore take the next step, conducting a detailed, quantitative investigation of the consequences of an impact. Using HNL specific crash rate, the expected frequency is 5.69E-4.

In this report, we have focused on the likelihood of an aircraft impact. The reason for the high probability we identified is the proximity of the proposed facility to active runways at HNL. If the proposed facility were located over ten miles from the center of the runways, the conditional probability would decline by a factor of 1,000, placing the yearly probability within the limits the NRC generally deems acceptable for nuclear

facilities. The NRC should consider in its environmental review alternate locations, which would substantially reduce risks to the public associated with aviation accidents.

The skid-in distance for air carrier operations appears to be the dominant factor behind the high risk to the Pa'ina irradiator. If the facility remains in its present location, the NRC must consider requiring Pa'ina to surround the facility with major obstructions, such as earthen berms, or substantially hardening the facility, to mitigate and minimize the threats to the public.

Potential aviation accidents include impacts into the proposed facility and into the irradiator itself. Based on experience with the 9/11 attack, it is crucial, in evaluating the consequences of an impact, to analyze the potential for a major fuel fire and explosion. The NRC and CNWRA improperly fail to consider such consequences, which could cause the loss of the Radiation Safety Officer and facility personnel, as well as the loss of electricity and monitoring instruments, all of which would prevent implementation of emergency procedures vital to protecting the general public. The fire and explosion from an airplane crash could also evaporate or displace the irradiator's shielding water or damage the irradiator pool, allowing the shielding water to escape. Sea water infiltrating through a breach in the pool structure could cause contamination of the pool water. Moreover, contaminated water could escape the facility through a breach in the pool structure, contaminating groundwater. Any of these eventualities could expose surviving facility personnel, emergency responders, the public and/or the environment to very high radiation doses.

A direct fly-in into the irradiator itself, particularly if the engine shaft of a military aircraft or major carrier were to strike the irradiator, could puncture the irradiator pool, leading to a loss of shielding water, and shatter the Co-60 pencils.[21] The forces exerted by such a crash would far exceed the impact standards set forth in 10 C.F.R. § 35.21 on which CNWRA bases its claim the public would be safe. The NRC and CNWRA need to provide data and calculations to back up their currently unsupported claims of "no significant impact."

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[21] This type of accident could also cause the loss of the RSO and facility personnel and the loss of electricity and monitoring instruments, with the serious consequences described above.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Pa'ina Hawaii, LLC Materials License Application	)))))	Docket No. 30-36974-ML ASLBP No. 06-843-01-ML

DECLARATION OF GEORGE PARARAS-CARAYANNIS, Ph.D. IN SUPPORT OF CONCERNED CITIZENS' CONTENTIONS RE: DRAFT ENVIRONMENTAL ASSESSMENT AND DRAFT TOPICAL REPORT

Under penalty of perjury, I, Dr. George Pararas-Carayannis, hereby declare that:

1. I have a Ph.D. in Marine Sciences from the University of Delaware, a M.S. in Oceanography from the University of Hawai'i, and both a B.S. in Chemistry-Mathematics and an M.S. in Chemistry from Roosevelt University. I have considerable experience in mathematical modeling and field studies of natural disasters, environmental engineering, coastal engineering, geology, seismology, volcanology, geophysics, risk analysis, disaster planning/mitigation, real time data systems, and hazard reduction.

2. I have been Oceanographer/Geophysicist or consultant to a number of government agencies including the State of Hawai'i, the Nuclear Regulatory Commission ("NRC"), the United States Army, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Smithsonian Institute, and numerous United Nations organizations.

3. I played a key role in the pioneering U.S. tsunami research efforts, when, with the late Professor Doak Cox, I developed the tsunami evacuation zones for the State

EXHIBIT 4

of Hawai'i. These tsunami evacuation zones are still used by the Hawai'i State Civil Defense today. My work has contributed significantly toward advances in tsunami research and tsunami warning technology around the world.

4. From 1974 to 1992, I was the Director of the United Nations Educational Scientific and Cultural Organization's Intergovernmental Oceanographic Commission International Tsunami Information Center in Honolulu.

5. As Oceanographer of the U.S. Army Corps of Engineers Coastal Engineering Research Center in Washington, D.C., I advised the NRC on nuclear power plant siting, evaluation of hurricanes and hurricane surge effects on nuclear power plants, and reviews of environmental impact statements.

6. I assisted the NRC with the licensing of units 2 and 3 of the San Onofre nuclear power plant in California and evaluated the potential effects of Gulf hurricanes and surges at the Crystal River Nuclear Power Plant in Florida. The latter study required a mathematical model for maximum probable hurricanes and the surges they can generate and the verification of the mathematical model with known historical Gulf hurricanes, beginning with the Galveston hurricane of 1900.

7. As a member of the American Nuclear Society, I co-authored the Society's National and International Environmental Standards for Nuclear Power Plants.

8. A true and correct copy of my resume, which contains additional information regarding my background and expertise, is attached hereto as Exhibit "8."

9. I have reviewed Pa'ina Hawaii, LLC's materials license application and supporting documents on file in this proceeding. I have also reviewed the Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the

Proposed Pa'ina Hawaii, LLC, Irradiator Facility, prepared by the Center for Nuclear Waste Regulatory Analyses ("CNWRA Report") and the NRC's Draft Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawaii ("DEA").

10. Based on my review of those documents, I prepared an independent assessment of the natural hazard risk and compared my analysis with the CNWRA Report and the DEA. A true and correct copy of my report, entitled "Assessment of Natural Disaster Risks for the Proposed Site of Pa'ina Hawaii, LLC's Cobalt-60 Irradiator Facility At 192 Palekona Street, Honolulu, Hawai'i," is attached hereto as Exhibit "9" and incorporated herein by reference.

11. For the reasons discussed in this declaration and analyzed in greater detail in my report, my opinion is that the DEA and CNWRA Report's conclusions that potential seismic, tsunami and hurricane activity would have no significant impacts on public health and safety from the proposed irradiator are based on inaccurate assumptions and faulty analysis. On the contrary, hurricanes, tsunamis, and earthquakes involving the proposed irradiator may have significant impacts that merit much more rigorous review.

12. The proposed irradiator site, which is adjacent to Ke'ehi Lagoon and the Honolulu International Airport, is relatively flat, at a low elevation, and within the State Civil Defense tsunami evacuation zone, making it potentially unsafe and susceptible to flooding by tsunamis and hurricanes and wind damage by hurricanes. Pa'ina also proposes to build its irradiator on unconsolidated sediments, posing a risk of damage from earthquakes due to liquefaction.

13. The proposed irradiator site presents risks to operation of a nuclear irradiator that could easily be avoided. Locating the site inland and away from the shores of Ke'ehi Lagoon would eliminate the risk of impacts from tsunami runup and hurricane storm surges. Siting the irradiator on solid ground, rather than unconsolidated fill, would lay to rest concerns about liquefaction during earthquakes.

14. **Risk of Hurricane Impact at the Irradiator Site.** Contrary to the CNWRA Report's analysis, a future hurricane could make landfall on O'ahu's southern shore or pass closer to the island, potentially impacting the irradiator site. The U.S. Navy estimated that there is an 80% probability that a hurricane or tropical storm will pass within 360 nautical miles of the Honolulu International Airport. It is misleading for the CNWRA Report to conclude that hurricanes are not a risk to the site merely because no hurricane on record had a direct landfall on O'ahu, as the historic record covers only a short period of time.

15. **Incorrect Assessment of Hurricane Surge Risk and Impacts.** The DEA and CNWRA Report err in assuming that hurricane surges and tsunami waves behave similarly. In fact, potential hurricane surges could result in longer and more extensive flooding at the site than tsunamis. Category 1 or 2 hurricanes can be expected to flood the proposed irradiator site by about 1-3 feet of water. In the event of a Category 3 or 4 hurricane, flooding of up to 5-7 feet is possible. The entire reef runway and the proposed irradiator site can be expected to flood. The DEA and the CNWRA Report do not consider potential consequences of flooding due to hurricane surges, such as failure of electric power supply, the destruction of back up generators, mixing seawater into the irradiator pool, or buoyancy forces (discussed below).

16. The DEA and the CNWRA Report completely overlook the proximity of the proposed site to the Ke'ehi Lagoon shoreline, and the long fetch of the Ke'ehi Lagoon along which hurricane wind frictional effects could add to other surge height components. Further, the CNWRA Report and the EA ignore the existence of past storm surge deposits in the area, which is confirmed in the applicant's Geoanalytical Report (p. 192). This indication of past storm surges requires the NRC to consider the potential surge flooding effects for the maximum probable hurricane scenario (i.e., a Category 4 event). My report discusses the maximum probable hurricane scenario in further detail.

17. The CNWRA Report erroneously concludes that since Iniki's storm surge measured 0.78 meters, or 30 inches, at a tide gauge inside Honolulu Harbor, that a hurricane surge could not reach above 30 inches in the future and, thus, the proposed site is safe. This station is a tsunami tide gauge station, which filters out the short-period storm waves that significantly contribute to greater maximum water level heights. Tsunami tide gauges do not give accurate or realistic measurements of expected hurricane surge inundation on the island. In fact, along the Wai'anae coast, Iniki's hurricane surge reached the second story of apartment buildings and houses and was extremely damaging.

18. Potential hurricane surge heights can be accurately predicted and quantified using mathematical models. Site-specific data, such as topography and tide, meteorological parameters, and other conditions are used to solve complex hydrodynamic equations of motion and continuity, to determine the time history of expected sea level change associated with the hurricane at any given point along a shore. The DEA and

CNWRA Report fail to perform any modeling, which is vital to accurately assess potential impacts from hurricanes.

19. The DEA and CNWRA Report also fail to consider buoyancy forces caused by a rise in sea level due to hurricane surge, a potentially significant impact. The Geoanalytical Report accompanying Paina's application states that approximately 760 pounds per square foot would be exerted against the bottom surface of the irradiator pool at foundation level. The buoyancy pressure at the foundation level can be expected to increase significantly under hurricane surge flooding conditions, but the DEA does not assess this impact or consider potential consequences, such as damage to the irradiator pool's integrity, lifting, or tilting, all of which could allow the pool's shielding water – and, if a source were breached, radioactive effluent – to drain into the surrounding environment.

20. **Incorrect Assessment of Potential Hurricane Winds.** The DEA and CNWRA Report's evaluation of maximum possible wind speeds at the proposed irradiator site is inaccurate. The data on which the CNWRA bases its assessment are insufficient, since they go back only to 1950, and the CNWRA incorrectly assumes future hurricanes will always pass south and west of O'ahu and never pass close to or make landfall on O'ahu. As both history and modeling (discussed in my report) confirm, a hurricane could make landfall on, pass close to, or pass to the north of O'ahu (as Hurricane Hiki did).

21. The designation of the irradiator site as Exposure Category C underestimates the maximum possible wind speeds. For example, Hurricane Nina's winds of up to 131 km/h (82 mph) at the Honolulu International Airport significantly

exceeded the maximum wind speeds for designation of the irradiator site to Exposure Category C. Even without landfall on O'ahu, a hurricane similar to Iniki (category 4), with as small of a diameter, passing south of O'ahu and heading in a northwest direction at a distance which corresponds approximately to the radius of its maximum winds, can be expected to have sustained winds of up to 225 Km/hr (about 140 mph) and gusts of as much as 280 Km/hr (175 mph) at the Honolulu International Airport.

22. The DEA's failure to consider potential consequences of hurricane winds ignores potentially significant impacts. For example, uprooted trees, grounded airplanes, airport hangar facilities, and other debris in the area can act as missiles flying through the air, causing structural damage to the facility. In addition, hurricane winds can cause nearby aviation fuel storage tanks to ignite, threatening fires at the facility.

23. **Risk of Tsunami Impact at the Irradiator Site.** There is a 100% statistical probability that a future major Pacific-wide tsunami will impact the Hawaiian Islands. Contrary to the CNWRA Report's claims, the proposed irradiator site is within a State Civil Defense tsunami evacuation zone, and evacuation will be mandatory if a tsunami warning is issued. Tsunami waves could be enhanced by the unique features of Ke'ehi Lagoon, causing a pile-up effect at the apex of the lagoon, which is near the proposed irradiator site. The waves could overtop Palekona Street and flood the site.

24. **Incorrect Assessment of Potential Tsunami Runup Risk.** The DEA and the CNWRA Report do not properly consider the risk of tsunami runup, failing to assess or even mention that the proposed irradiator site is in a State Civil Defense tsunami evacuation zone. The CNWRA Report also incorrectly states Honolulu International Airport is outside the tsunami evacuation zone. In fact, the Civil Defense

maps I helped develop show that the entire reef runway and various airport facilities are within the zone of potential tsunami inundation.

25. The CNWRA Report relies on inaccurate information provided by the State of Hawai'i's Department of Transportation that "the south shore of O'ahu has never sustained more than a 3 [foot] wave from any tsunami since 1837." Contrary to this assertion, the historic runup record shows that a 1946 tsunami reached a maximum runup on O'ahu's southern coast of 31 feet, the *O'ahu Tsunami Runup Maps* show that the 1957 and 1960 tsunamis had maximum runups of 9 feet on O'ahu's south shore, and three Chilean earthquakes generated tsunamis with runup in Honolulu of over 8 feet in 1837, over 5 feet in 1868, and nearly 5 feet in 1877.

26. The CNWRA Report inaccurately relies on tide gauge recordings as evidence of low tsunami runup. Tide gauges filter out short period waves, giving smaller runup heights.

27. The DEA and the CNWRA Report fail to distinguish between tsunami runup heights (a vertical measurement) and tsunami inundation limits (horizontal measures of inland penetration of a tsunami's waves). In low-lying areas, tsunami inundation can extend inland for several hundred yards, even with relatively low runup.

28. The DEA and the CNWRA Report do not consider resonance effects or cumulative pile-up that could occur within Ke'ehi Lagoon and cause higher runup at the proposed irradiator site than on the open coast and fail to take into account potential damage from strong currents and resonance generated by certain periods of tsunami waves within Ke'ehi Lagoon, which can increase runup.

29. The DEA and the CNWRA Report fail to adequately quantify runup potential with a proper numerical modeling study.

30. **Incorrect Assessment of Potential Tsunami Impacts.** The CNWRA Report's and DEA's reliance on a "stylized fluid dynamic calculation" to assess tsunami impacts demonstrates a lack of understanding of a tsunami's terminal characteristics when it moves over land. Over land, there is no structured wave form, but rather a chaotic turbulent water mass that is unlikely to create wave velocities sufficient to pull a cobalt-60 source assembly out of the irradiator pool.

31. The DEA and CNWRA Report ignore the most likely result of a tsunami, flooding at the proposed irradiator site. To assess tsunami impacts, the NRC must evaluate the consequences of tsunami-related flooding, such as the failure of peripheral equipment, power and back up generators, dispersal of leaking pool water, and grounded aircraft or equipment carried and crushing against the irradiator facility, which could affect the integrity of the pool, draining the water below the minimum level needed to shield the Co-60 sources when the flood waters recede.

32. **Risk of Liquefaction at the Irradiator Site.** Earthquakes have damaged Honolulu buildings in the past. The CNWRA Report and the DEA ignore the potential focusing effects of seismic energy on O'ahu, which can intensify ground motion, even for earthquakes with small magnitudes.

33. Pa'ina proposes to build its irradiator on unconsolidated alluvial sediments (i.e., gravel and sand), where liquefaction can occur, particularly if earthquake ground accelerations exceed 0.20 g due to focusing of seismic waves.

34. The CNWRA Report improperly trivializes the potential intensity of ground motions and liquefaction potential at the proposed irradiator site, inaccurately assuming the Modified Mercalli Intensity V estimated for the island of O'ahu for the October 2006 earthquake is the maximum earthquake ground force that can be expected at the proposed site. There is no basis for this assumption since, unlike magnitude, which represents a single quantity of an earthquake's energy release, intensity does not have one single value for a given earthquake. Rather, it can vary significantly from place to place depending on substrata soil conditions. There is no evidence the Modified Mercalli Intensity estimate on which the CNWRA Report relied took into account the properties of unconsolidated sediments like those found at the irradiator site. Additional analysis is needed to assess properly the risks earthquakes pose to the proposed irradiator.

I declare under penalty of perjury that the factual information provided above is true and correct to the best of my knowledge and belief, and that the professional opinions expressed above are based on my best professional judgment.

Executed at Honolulu, Hawai'i on this 9th day of February, 2007.

[signature]

Dr. George Pararas-Carayannis
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ASSESSMENT OF NATURAL DISASTER RISKS FOR THE PROPOSED SITE OF PA'INA HAWAII, LLC'S COBALT-60 IRRADIATOR FACILITY AT 192 PALEKONA STREET, HONOLULU, HAWAI'I

Prepared for:

Earthjustice
223 South King St., Suite 400
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Prepared and authored by:

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Consulting Oceanographer, Geophysicist

February 2007

EXHIBIT 5

TABLE OF CONTENTS

SUMMARY

This report assesses the risks posed by Pa'ina Hawaii, LLC's proposed Cobalt-60 food irradiator (Irradiator) in the event of a natural disaster and analyzes the Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Proposed Pa'ina Hawaii, LLC, Irradiator Facility, prepared by the Center for Nuclear Waste Regulatory Analyses (CNWRA Report), which supports the Nuclear Regulatory Commission's (NRC's) Draft Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawai'i (DEA).[1]

The proposed Irradiator site, which is adjacent to Ke'ehi Lagoon and the Honolulu International Airport, is relatively flat, at a low elevation, and within the tsunami evacuation zone, making it susceptible to flooding by tsunamis and hurricanes and wind damage by hurricanes. It is also proposed to be built on unconsolidated sediments, posing a risk of damage from earthquakes due to liquefaction. Therefore, this site presents risks to operation of a nuclear irradiator that could easily be avoided by siting the facility at a location away from the water's edge and on solid ground. To protect the public and the environment from unnecessary risk, the NRC ought to consider alternate siting locations.

Hurricanes: Weakness in the semi-permanent subtropical high-pressure ridge north of the Hawaiian Islands can allow a hurricane to hit on or near O'ahu and the proposed Irradiator site. There is an 80% estimated probability that a hurricane or tropical storm will pass within 360 nautical miles of the Honolulu Airport. In the event of the maximum probable hurricane landing on O'ahu, maximum sustained winds could reach up to 140 mph and gust up to 175 mph, with severe flooding due to intense storm surges. Smaller hurricanes could also cause flooding from the Ke'ehi Lagoon. The CNWRA Report and the DEA incorrectly assess the risks and effects of hurricane-force winds and storm surges.

Tsunamis: There is a 100% statistical probability that a future major Pacific-wide tsunami will impact the Hawaiian Islands, and the proposed Irradiator site is within a State Civil Defense tsunami evacuation zone. Because damaging tsunami effects, such as runup and strong currents, are exacerbated by the unique features of harbors and basins such as the Ke'ehi Lagoon, a pile-up effect could occur at the head of Ke'ehi Lagoon near the proposed Irradiator site. Enhanced tsunami waves could overtop Palekona Street and flood the site.

The CNWRA Report and DEA's reliance on the stylized fluid dynamic calculation to determine that a tsunami will not have a significant impact ignores other potential effects of tsunamis, such as flooding, which can be exacerbated in semi-enclosed bodies of water. Also, several factual inaccuracies were identified, including the assertion that the airport is not in a tsunami evacuation zone, and the statement that runup on south O'ahu has not exceeded 3 feet since 1837.

Seismic Hazards: Earthquakes have damaged Honolulu buildings in the past. The CNWRA Report and the EA trivialize the possible effects of liquefaction on the Irradiator, proposed to be

[1] This document attempts to use correct Hawaiian spelling, however, the author will use the spelling of the official business name "Pa'ina Hawaii, LLC".

built on unconsolidated alluvial sediments (i.e., gravel and sand). They also ignore the potential focusing effects of seismic energy on O'ahu, which can intensify ground motion, even for earthquakes with small magnitudes. Further, there is no proper analysis of the sufficiency of the load-bearing soil.

INTRODUCTION

Purpose and Scope

This report analyzes the potential impact of natural disasters on the proposed Pa'ina Hawaii Irradiator site and structure adjacent to the Honolulu International Airport reef runway and Ke'ehi Lagoon. The natural disasters with the greatest potential to affect the site – hurricanes, tsunamis, and earthquakes – are discussed in detail. A historical description and geographical delineation and distribution of each is provided, along with a discussion of the risks and consequences of a natural disaster event at the proposed Irradiator site.

This risk assessment is based on thorough research and analysis of all potential natural disasters specific to the proposed facility site and review of all available government databases, institutional reports, and public records, including the background materials provided by Pa'ina Hawaii's application to the NRC. The conclusions also analyze the DEA and CNWRA Report.

Physical Location and Description of the Proposed Cobalt-60 Irradiator Site

The proposed Irradiator site is about 375 feet from the Ke'ehi Lagoon shoreline and adjacent to the Honolulu International Airport reef runway at 192 Palekona Street. The site elevation is about 5-6 feet from mean sea level, but less than 3 feet during the highest spring tide. Seawalls and rock revetments surround the airport runways on the shores of both the ocean and Lagoon to prevent shoreline erosion, including at the end of Palekona Street, however, there are no berms or other physical barriers between the site and Ke'ehi Lagoon.

According to the Geoanalytical Report filed with Pa'ina Hawaii's NRC application, the entire area, including the shoreline, airport, and proposed site is comprised of "an eight-foot-thick zone of fill consisting of silty sand and gravel," and "the upper three feet of this fill is generally compact to dense, but the remainder is soft or very loose." This fill was removed from Ke'ehi Lagoon to reclaim land for sections of the airport, including the reef runway, and the surrounding industrial tracts. The extensive land reclamation has transformed the Ke'ehi Lagoon coastline. According to the Geoanalytical Report, "the fill overlies typically very loose to semi compact gravel and sand lagoon sediments to a depth of about 24.5 feet, below which are storm surge deposits composed of a dense, salty, gravelly sand to the maximum depth explored, about 36.5 feet. Ground water was intercepted at an average depth of about eight feet, near the contact between the fill and the marine soils."

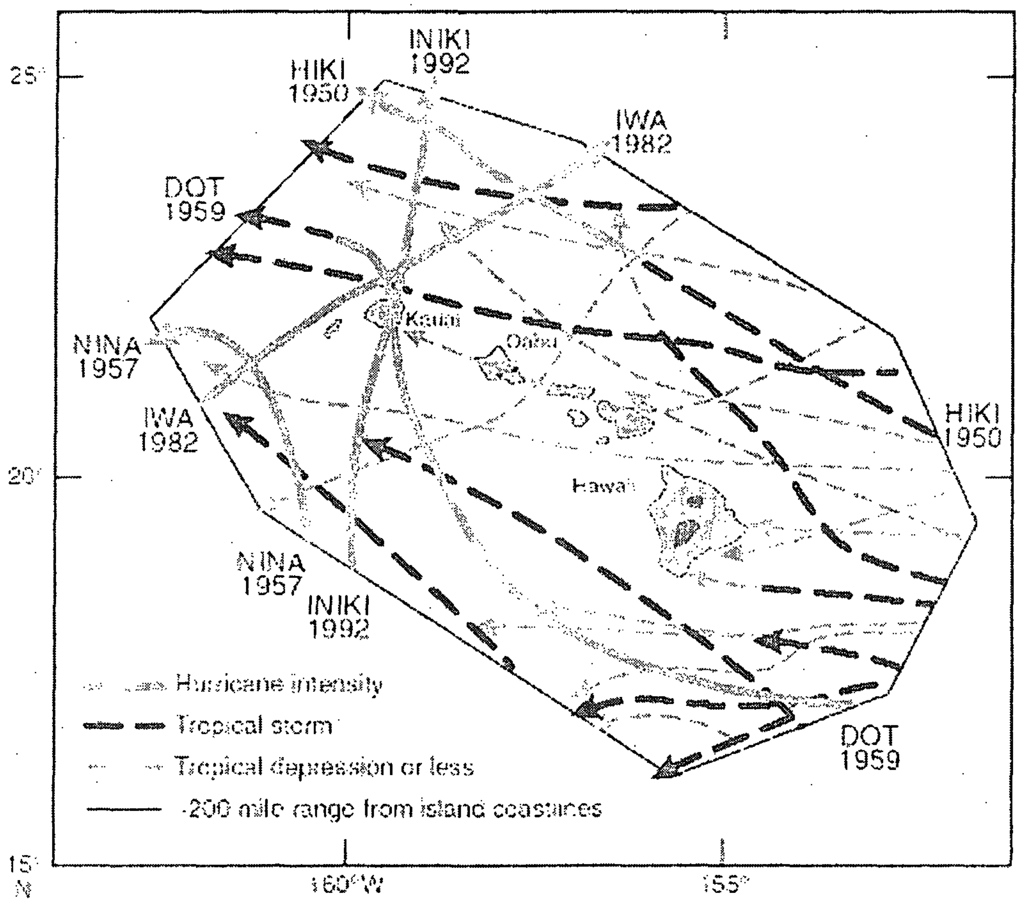
HURRICANE HAZARDS

Storm surges associated with hurricanes present the greatest hazard risk for the proposed Irradiator site. High winds are also a concern. This section provides a detailed description of recent historical hurricanes in Hawai'i, as well as an extensive analysis of the risk of the

proposed Irradiator site from potential future events. The description and the risk analysis are based on tables, charts, historical hurricane storm tracks, and data (water levels/barometric pressure, winds, waves, and tides) obtained from numerous reliable sources.

Historical Hurricanes and Storm Systems in the Hawaiian Islands

As detailed below, at least three major hurricanes have passed near or over the islands in the last 50 years, generating strong winds, heavy rains, and flooding – Iniki (1992), Iwa (1982), and Dot (1959). Although all three were centered over or near Kaua'i, O'ahu was considerably impacted, particularly along the southern and west coasts. Prior to these hurricanes, tropical depressions Hiki (1950) and Nina (1957) caused strong winds, heavy rains, and flooding on O'ahu. The diagram below illustrates the path of hurricanes, tropical storms and depressions near the Hawaiian Islands in recent years.



Tracks of recent hurricanes, tropical storms and depression in the Hawaiian Island Region.

Hurricane Dot – July 24 - August 8, 1959. Dot formed as a tropical storm in the eastern Pacific, west of Baja California. Dot tracked west northwest gaining strength until it passed within 90 miles of Hawai'i Island's South Point as a Category 4 hurricane. Dot turned northwest

and made landfall on the island of Kaua'i as a Category 1 hurricane. Kaua'i was declared a disaster zone, with substantial damage to homes and utility lines. Damage to the agriculture industry was estimated at $5.5–$6 million in 1959 dollars. On O'ahu, flooding from heavy rainfall, wind damage, and high waves caused damage over $300,000 in 1959 dollars.

Hurricane Iwa - November 19- 25, 1982. Iwa formed as a tropical storm and reached Category 1 hurricane status near the Island of Kaua'i. The highest sustained winds reached 90 mph, with sudden gusts exceeding that velocity. When its energy finally dissipated, Iwa had taken one life and devastated the islands of Ni'ihau, Kaua'i and O'ahu with property damage amounting to over $250 million in 1982 dollars. On Wheeler Air Force Base on O'ahu, winds were measured at 45 knots from the North/Northwest, gusting to 68 knots. At Barber's Point the winds were from the Southwest at 37 knots and gusting to 61 knots.

Hurricane Iniki - September 5 - 13, 1992. Category 4 hurricane Iniki is the most destructive hurricane to hit the Hawaiian Islands in the 20th Century, and up until the 2005 hurricane Katrina, was the third most damaging hurricane in U.S. history.

Iniki's Formation: Iniki formed as a tropical depression southwest of Baja California. As it moved westward into the Central Pacific, it began to intensify and was upgraded to a tropical storm. It continued to strengthen while on a west-northwest course, and was upgraded to a hurricane, as it passed 300 miles south of Hawai'i. 385 miles SSW of Hilo, its maximum sustained winds reached 85 knots. Iniki continued west-northwest at a speed of translation ranging between 12 and 15 knots until it reached 425 miles south of Honolulu, where it began to slow its forward motion speed (speed of translation) and move in a westward direction at 10 knots. At the time, maximum sustained winds reached 100 knots with a central pressure of 951 millibars. Iniki slowed even more and started to turn northwest, and about 400 miles south of Kaua'i, it strengthened with maximum winds estimated at 110 knots and gusts up to 135 knots.

Iniki continued to strengthen and accelerated as it turned more northward. Hurricane warnings were extended eastward to include the island of O'ahu. Increased maximum sustained winds were estimated at 125 knots with gusts as high as 150 knots, and the central pressure was recorded at 938 millibars, the lowest ever recorded in a central Pacific hurricane up to that time.

Iniki's Landfall and Departure: In the afternoon of September 11, the eye of Iniki crossed Kaua'i's south coast, with maximum sustained winds estimated at 145 mph over land, and gusts up to 175 mph miles. After centering 50 miles north over Kaua'i's Nā Pali coast, the hurricane warning for O'ahu was downgraded to a tropical storm warning, then cancelled.

Iniki's Damage and Destruction: Iniki's most severe wind conditions on O'ahu were measured at Wheeler Air Force Base - winds of 29 knots from the Southeast, gusting to 47 knots. At Barber's Point the winds were from the Southeast at 34 knots gusting to 45 knots. Iniki produced tides of 1.7–3 feet (0.5–0.9 m) above normal on O'ahu. Prolonged periods of storm waves superimposed on the elevated sea level severely eroded and damaged O'ahu's southwestern coast, particularly Barbers Point through Ka'ena Point. The Wai'anae coastline experienced the most damage on O'ahu, with waves and storm surge flooding the second floors

of beachside apartments. Hurricane Iniki ultimately caused 2 deaths on O'ahu and several million dollars in property damage.

On Kaua'i, storm tides ranged from 4.5 to 6.3 feet above normal, with 20 to 35 foot storm waves battering south Kaua'i. Maximum flooding began at the peak of the astronomical tide, and was augmented by reduced barometric pressure. Inundation was reported at between 22-29 feet above mean lower low water (MLLW). Property damage caused by Iniki reached close to $3 billion. 1,421 homes were completely destroyed, 5,152 suffered major damage, and another 7,178 received minor damage. Electric power and telephone service were lost throughout the island, and four weeks after the storm, only 20 percent of the island's power had been restored. Crop damage was extensive, with sugar cane stripped, banana and papaya crops destroyed, and fruit and nut trees broken or uprooted.

<u>Hurricane and Storm Surge Risk Assessment for the Proposed Irradiator Site</u>

Strong hurricane winds and storm surges can impact the proposed Irradiator site. Flooding due to potential storm surges present a high risk for damage in the event of a hurricane. The following is a brief overview of the basic concepts used to predict and quantify surge components that cumulatively contribute to the generation of hurricane surge flooding.

Hurricane Surge

Extreme coastal water fluctuations during hurricane events are caused by a number of factors. Cumulative hurricane surge height on an open-ocean coast depends on components such as atmospheric pressure variation, the phase of astronomical tide, storm intensity, size, path, duration over water, speed of translation, winds and rainfall, initial water level rise, and surface waves and associated wave setup and runup due to wind frictional effects. The bathystrophic component is another important parameter of the coastal hurricane surge. In the northern hemisphere, hurricane winds approaching a coast have a counterclockwise motion. Because of the Coriolis effect caused by the earth's rotation, the flow of water induced by the cyclonic winds deflect to the right, causing a rise in the water level. Therefore, the bathystrophic storm tide is important in producing maximum surge even when the winds blow parallel to the coast.

To what extent the bathystrophic component will add to the flooding at a specific site on the coast depends on the storm's direction of approach. Thus, the proposed Irradiator site could be flooded to a greater extent if the hurricane makes landfall westward of the site, rather than to the east. However, even if a hurricane does not make landfall on O'ahu but passes considerably south of the island and is moving in a west/northwest direction at a distance of 150 miles or less, flooding of the Irradiator site could occur.

In a semi-enclosed basin, such as Ke'ehi Lagoon, coastal morphology, direction of hurricane approach, radius of maximum winds, coastal configuration, and geometry of the basin also affect water level rise and the degree of surge flooding. An example is hurricane Katrina, which resulted in a higher surge approaching from Lake Pontchartain, rather than from the Gulf of Mexico, causing New Orleans levees to overtop and fail.

Prediction and Quantification of Hurricane Surge

Difficulties arise in the prediction of surge flooding because a hurricane is a three dimensional weather system, with ever-changing dynamic meteorological and oceanic conditions, such as wind speeds, directions, and atmospheric pressures. Predictions are primarily based on analytic and mathematical models, which estimate interactions between winds and the ocean. Numerical models develop the three dimensional wind field of a hurricane, the radius and changing direction of maximum winds, the landfall, and the resulting storm surge flooding.

The simplest quasi-one-dimensional model is a steady-state integration of stresses of the hurricane winds on the surface of the water from the edge of the Continental Shelf to the shore. Sophisticated mathematical models have been developed in recent years to provide more accurate three-dimensional estimates of energy flux and flooding that can be caused by a passing hurricane. All mathematical models, regardless of sophistication of methodology, must use the Bathystrophic Storm Tide Theory. The NRC has used numerical models in the past *(e.g. "Pararas-Carayannis 1975 - Verification Study of a Bathystrophic Storm Surge Model", Technical Memorandum No. 50, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington D.C., May 1975 - supported by the NRC for the licensing of the Crystal River nuclear plant in Florida).*

To model a hurricane and calculate maximum surge heights, certain meteorological parameters must be determined, including the hurricane's central pressure index, its peripheral pressure, the radius to maximum winds, the maximum gradient wind speed, the maximum wind speed, and the speed of hurricane translation (i.e., overall speed of the system). The models must also integrate the astronomical tide, existing ambient wave conditions, ocean surface and bottom friction, and coastal topography. Once these parameters are established, complex hydrodynamic equations of motion and continuity are applied, which are then solved to determine the time history of expected sea level change associated with the hurricane at any given point along a shore. Most hurricane surge numerical model predictions are fairly accurate and have been verified with historical data. Recently developed numerical models using a three dimensional approach, faster and more efficient computers, and more accurate weather data from satellites, have greater potential for more accurate predictions.

Statistical Probability of a Tropical Storm or Hurricane Striking O'ahu

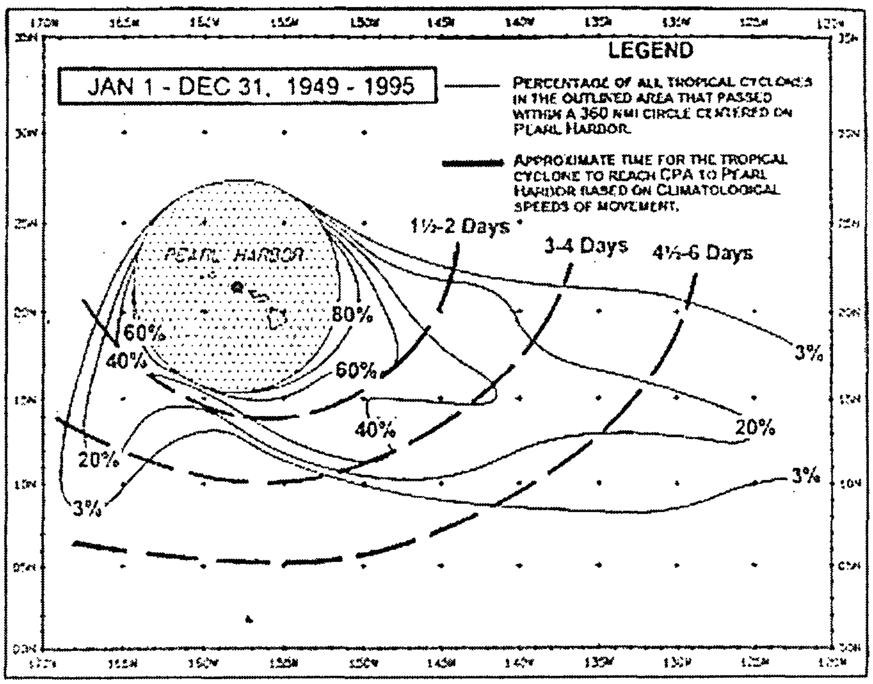
Hurricanes similar in intensity to Iniki or Iwa can be expected to occur again near the Hawaiian Islands, and could make landfall on O'ahu or pass close to the island. For example, as Iniki's track shows, the hurricane was heading for an almost direct hit of O'ahu 24 hours before changing direction, with the potential for much greater death and damage. Generally, a semi-permanent subtropical high-pressure ridge northwest of the Hawaiian Islands helps to keep hurricanes south of the islands. The western edge of this high-pressure ridge deflected Iniki's path from making landfall on O'ahu or passing closer, in 1992.

Nonetheless, the high-pressure ridge can develop weaknesses, and there is no guaranty that it will always be strong enough to deflect hurricanes away from the islands. This situation occurred in September 1992, when a large low system or trough began to drift south along and

just east of the International Dateline, causing the high-pressure system to weaken. The change in air mass flow caused Iniki to change its path northward, bringing it closer to the islands. If the large low system had been further east of the International Date Line, or if there were additional weakness of the Pacific High that had occurred a day earlier, Iniki could have made landfall on O'ahu. Hurricane Iwa is another example of how unexpected steering flow changes can occur. Even though Iwa appeared to be too far west of the islands and heading north, its path suddenly changed to the northeast, and the hurricane made landfall on Kaua'i.

Abrupt changes in atmospheric circulation have become more frequent in recent years, perhaps because of global warming and a more intense El Nino ocean circulation. For example, in 2006, anomalies in the flow of the jet stream caused atmospheric changes in the Central Pacific that caused four months of heavy rains and flooding in the Hawaiian Islands. Thus, it is possible that more frequent weakening of the Pacific High will occur in the future, allowing hurricanes to travel closer to the Hawaiian Islands.

The U.S. Navy has determined that there is a 80% probability of a tropical storm or hurricane passing within 360 nautical miles of Pearl Harbor (Department of Navy, Hawai'i Region, Civil Emergency Management Program Manual - Instructions for Hurricane Preparedness by Naval activities on Oahu in COMNAVBASEPEARLINST 3440.7, Pearl Harbor and Honolulu Harbor Hurricane Haven Study, Fig. 14. (see map below)). The Navy study, which was based on 27 tropical storms and hurricanes occurring from 1949-1995, indicates that there is a 20% probability that storm systems will approach O'ahu from the east-southeast direction, which would facilitate the maximum probable hurricane scenario discussed below.



Probability that a tropical storm or hurricane will pass within 360 nmi of Pearl Harbor, and approximate point of approach (CPA) (Pearl Harbor study).

Maximum Probable Hurricane Impact Scenario for the Proposed Irradiator Site

The maximum probable hurricane (MPH) at the Irradiator site would result from a Category 4 hurricane, similar in intensity to Iniki, approaching Honolulu from a southern or an east-southeast direction and making landfall west of the proposed Irradiator site at a distance corresponding to the radius of its maximum winds. The following analysis provides documentation in support of such hurricane occurrence and estimates of expected winds and surge inundation at the Irradiator site.

Sequence of Potential Winds and Surge Flooding at the Proposed Irradiator Site in Event of a Maximum Probable Hurricane on O'ahu

The following analysis provides a probable time history of wind and surge flooding effects that could be expected at the Irradiator site in the event of a MPH (category 4) with landfall near Barber's Point. Under this scenario, the proposed Irradiator site, Honolulu Airport, and the rest of O'ahu would be in the dangerous semicircle of the hurricane's impact. Sustained winds could reach up to 140 mph, with gusts up to 175 mph, and flooding would be severe.

Potential Winds: When the center of the MPH is about 180-200 miles south or southeast of Honolulu, there will be strong winds at the proposed Irradiator site, with gusts up to 35-40 mph. When the hurricane's center is about 130 miles south of Honolulu, the gusts could increase to about 55 mph. As the MPH moves closer, winds at the site will be from the east northeast with sustained speeds of 55 mph, gusting to about 60-65 mph. Wind damage will begin in the area and sea level will start rising, both in the Ke'ehi Lagoon and the open coast along the reef runway.

As the MPH gets even closer to Honolulu, the winds in the airport area will be from the east (090) with average sustained speeds of about 80 mph and gusts ranging from 115 mph to 140 mph. Because the wind design threshold of 80 to 100 mph that applies to most of the buildings within the Honolulu airport will be exceeded, gradual wind damage will begin.

As the center of the MPH nears the Honolulu coastline (perhaps 40 miles away or closer), winds will be down slope and at their strongest. Thus, maximum winds can be expected along the southern coast of O'ahu at the proposed Irradiator site before the hurricane's eye makes landfall. Maximum sustained winds will be from an east-southeast direction at speeds of about 140 miles per hour with peak gusts up to 175 miles per hour. At this time, major damage to the airport hangar buildings in the area will occur. Also, the frictional effects of the wind will be in a landward direction along Ke'ehi Lagoon.

Potential Hurricane Surge Flooding Effects: The flooding effects at the proposed Irradiator site, the reef runway, and the entire southern and eastern coast of O'ahu will vary depending on the hurricane speed of translation when it is near or over the island. A slow moving hurricane with very low central barometric pressure (950 mm) will cause more flooding than a fast moving one. Because the end of Palekona Street is at the apex of the Keehi Lagoon, flooding will begin near the Irradiator site.

Maximum flooding of 5 to 7 feet will occur if the hurricane makes landfall near the time of the highest astronomical tide (spring tide). After the center of the MHP crosses the southern coast of O'ahu near Barber's Point, the wind direction can be expected to change rapidly from the eastern direction to south-southeast and then to a southern direction. Maximum surge flooding will begin to occur along the ocean side of the reef runaway, and the protective wall will be breached completely.

At this time, wind friction, the bathystrophic component, and the wave setup will be at a maximum along the reef runway. Coupled with the maximum astronomical tide and the rise in sea level due to reduced atmospheric pressure (as the hurricane center passes), maximum flooding will result along O'ahu's south coast and east of the hurricane's trajectory path. Storm waves will be superimposed on the elevated sea level and intensified at the proposed Irradiator site when the landward component of wind friction aligns along the 3-4 mile fetch within Ke'ehi Lagoon, causing a pile-up of waves at the end of Palekona Street, and flooding the proposed Irradiator site from the Lagoon.

Conclusions: Both winds and flooding from a severe hurricane could adversely impact the Irradiator site, resulting in damage to the facility's superstructure. Additional collateral damage could result from hurricane winds and surges uprooting trees and damaging airport hangar facilities and grounded airplanes. The airplanes, trees, and other debris in the area could act as missiles flying through the air and structurally damage the facility. Because nearby aviation fuel storage tanks could ignite, fire is also a potential hazard.

Because of its low elevation, the proposed Irradiator site is also vulnerable to damage by small hurricanes and hurricanes that do not pass directly over or near O'ahu. As discussed above, for example, even with Iniki passing far from O'ahu, the Wai'anae coastline experienced flooding reaching the second floor of beachside apartments. Category 1 or 2 hurricanes can be expected to flood the proposed Irradiator site by about 1-3 feet of water. In the event of a Category 3 or 4 hurricane, inundation of up to 5-7 feet is possible, due to the combination of storm surges and storm waves. The entire reef runway and the proposed Irradiator site can be expected to flood.

The applicant's Geoanalytical Report confirms the existence of past storm surge deposits in the area (p. 192). In view of such considerations, the engineering design of the proposed Irradiator must take into consideration at least the wind and surge flooding effects for the MPH scenario described above, which is for a Category 4 event.

In addition, the Geoanalytical Report states that approximately 760 pounds per square foot would be exerted against the bottom surface of the Irradiator pool at foundation level. The buoyancy pressure at the foundation level can be expected, however, to increase significantly under hurricane surge flooding conditions. Therefore, an additional buoyancy assessment of the proposed irradiator pool for various flooding levels must be performed to ensure the pool (1) will maintain its integrity (i.e., not be breached) and (2) will not tilt, losing vital shielding water and possibly damaging the Cobalt-60 sources, under hurricane surge flood conditions.

Comments on CNWRA Report and EA's Hurricane Analysis

Incorrect Assessment of Potential Peak Winds at the Proposed Irradiator Site – The CNWRA evaluation of maximum possible wind speeds of 168 km/h [105 mph] (the American Society of Civil Engineers standard) at the proposed irradiator site is insufficient. The designation of the site as Exposure Category C contradicts the CNWRA Report's correct assertion that Hurricane Nina (in 1957) produced record winds with gusts of 131 km/h [82 mph] at the Honolulu International Airport.

Also, the CNWRA's analysis and conclusions are based on data that goes back only to 1950, and incorrectly assumes that all future hurricanes in the region always pass south and west of O'ahu and that none will ever pass closer or make landfall on the island. As discussed above, this is simply not correct. Hurricane Hiki in 1950 passed north of O'ahu. Other tropical storms passed directly over O'ahu. In 1957, Nina – only a category 1 hurricane - passed at a distance which was even further west of O'ahu than that of hurricanes Iniki (1992) and Dot (1959). Nina's record winds of up to 131 km/h [82 mph] at the Honolulu International Airport significantly exceeded the maximum wind speeds for designation of the irradiator site to Category C Exposure.

The American Society of Civil Engineers standard designating maximum possible wind speeds of 168 km/h (105 mph) represents an underestimate for the proposed site, even if a hurricane passes to the south and west of O'ahu. Even without landfall on O'ahu, a hurricane similar to the 1994 Iniki (category 4), with as small of a diameter, passing south of O'ahu and heading in a northwest direction at a distance which corresponds approximately to the radius of its maximum winds, can be expected to have sustained winds of up to 225 Km/hr (about 140 mph) and gusts of as much as 280 Km/hr (175 mph) at the Honolulu International Airport.

The conclusion that there is no danger to the proposed site because no hurricane on record had a direct landfall on O'ahu is misleading. The historic record on storms and hurricanes in the Hawaiian Islands covers only a short period of time. Contrary to the CNWRA analysis, as discussed above, a future hurricane could make landfall on O'ahu's southern shore or pass closer to the island.

Incorrect Assessment of Hurricane Surge Risk - The CNWRA and EA hurricane surge risk analysis for the proposed irradiator site is unrealistic. The CNWRA Report applies the "stylized fluid dynamic calculation" prepared for the tsunami risk analysis (discussed at page 18 below), and concludes that because tsunami waves cannot generate the "wave velocity and shear forces necessary to create a vortex inside the pool that would pull a radioactive Co-60 source assembly out of the irradiator pool," then it follows that hurricanes waves could not either. First, the conclusion is based on the erroneous presumption that hurricane surges and tsunami waves behave similarly, which they do not. For example, tsunami waves have shorter periods than hurricane surges, so hurricane surges can create flooding at the site that will last considerably longer than flooding from tsunami waves.

Second, the analysis incorrectly assumes that the only safety consideration for the proposed Irradiator site is wave velocity lifting the radioactive source from the pool. Forces other than

drag force could affect the safety of the Irradiator if flooded by storm surges. For example, buoyancy forces from a rise in sea level due to hurricane surge may lift or tilt the Irradiator pool and radioactive effluent could drain into the surrounding environment. The CNWRA Report also ignores other effects of potential hurricane surges to the safety of the site, such as failure of electric power supply, the destruction of back up generators that are needed to run Irradiator pumps, possible fires from nearby fuel depots, aircraft or equipment crushing against the Irradiator facility, or concurrent wind effects on the facility, and the mixing of seawater into the Irradiator pool.

Incorrect Assessment of Potential Hurricane Surge Heights - The CNWRA Report incorrectly assesses the height of sea level flooding that can be expected on O'ahu from potential storm surges and downplays the impact on the safety of the Irradiator. It concludes erroneously that none of the hurricanes that have passed near O'ahu since the 1950's "have produced a storm surge that would pose a hazard to the facility." The Report incorrectly assumes that storm surges "appear to be bounded by the more significant wave heights that could be generated by tsunamis." In fact, potential hurricane surges could result in longer and more extensive flooding at the site than from tsunamis. The analysis completely overlooks the proximity of the proposed site to the shoreline of Ke'ehi Lagoon, and the long fetch of the Lagoon along which hurricane wind frictional effects could add to other surge height components. Because the applicant's Geoanalytical Report confirms the existence of past storm surge deposits in the area (p. 192), the CNWRA Report and the EA are deficient in their failure to take into consideration the wind and surge flooding effects for the MPH scenario (i.e., a Category 4 event).

The EA bases its conclusion of no significant impact on Table 3.3, which lists the historical tropical cyclones within 322 km (200 mi) of Honolulu International Airport and the associated maximum water levels above mean sea as recorded by the National Water Level Observation Network and referenced to Honolulu Station 1612340. Based on this limited database for the Honolulu station only, the CNWRA report concludes that since the maximum water-level produced by Iniki in 1992 was 0.78 m (2.6 ft) at this station, this represents the maximum possible water-level of hurricane surge that can be expected in the future, and therefore this assures the safety of the proposed site.

The CNWRA conclusion is erroneous. The value of 2.6 ft above mean sea level for Iniki, which was recorded by the Honolulu Station (owned and maintained by NOAA's National Ocean Survey), and the 2.6 ft height that is given, represents an instrumental recording by a tide gauge inside the harbor (at end of Pier 4). This station, which is also a tsunami tide gauge station, filters out the short-period storm waves that contribute to the total hurricane surge heights. The storm waves superimpose on other component parts of the hurricane surge and contribute significantly to greater maximum water level heights of the destructive hurricane effects (Pararas-Carayannis, 1975). Such tide gauge measurements do not, therefore, give accurate or realistic measurements of expected hurricane surge inundation on the island. In fact, along the Wai'anae coast, Iniki's hurricane surge reached the second story of apartment buildings and houses and was extremely damaging.

TSUNAMI HAZARDS

As detailed below, the proposed Irradiator site is within the O'ahu Civil Defense tsunami evacuation zone and is at risk of flooding from tsunamis. This section provides a detailed description of recent tsunami events in Hawai'i and analysis of the risk from potential future tsunami events on the proposed Irradiator site.

Tsunami Hazard Risk Assessment

The primary source of historical tsunami data is the "Catalog of Tsunamis in the Hawaiian Islands," (Pararas-Carayannis 1967, 1974, 1977) published by the Hawai'i Institute of Geophysics of the University of Hawai'i, updated in 1974 by the World Data Center A-Tsunami, and further updated in 1977 by the World Data Center -A for Solid Earth Geophysics (U.S. NOAA).

The runup data for major tsunamis impacting Hawai'i in 1946, 1952 1957, 1964 and 1975 is based on original measurements and observations initially plotted on the U.S. Geological Survey Topographic Quadrant Maps (Scale, 1:24,000) at the Hawai'i Institute of Geophysics (HIG) (Pararas-Carayannis, 1964, 1965, 1967). These maps were subsequently summarized and republished on charts supplied to the State Tsunami Observation Program and Civil Defense agencies (Walker 2002). The National Geophysical Data Center also compiled secondary data from the original HIG maps (Lander and Lockridge, 1989).

Historical Pacific-wide and locally generated tsunamis affecting O'ahu

The following overview discusses the six major tsunamis that have affected south O'ahu in the last 50 years – 1946 (Aleutians), 1952 (Kamchatka), 1957 (Aleutians), 1960 (Chile), 1964 (Alaska), and 1975 (Hawai'i).

April 1, 1946 Aleutian Tsunami - One of the most destructive Pacific-wide tsunamis was generated by a magnitude 7.8 earthquake near Unimak Island in Alaska's Aleutian Island chain. A 35-meter wave completely destroyed the U.S. Coast Guard's Scotch Cap lighthouse on Unimak, killing all five occupants. Five hours later, destructive tsunami waves reached the Hawaiian Islands and completely obliterated Hilo's waterfront on the Big Island, killing 159 people. At the Big Island's Laupahoehoe Point, waves reached up to 8 meters and destroyed a hospital and a school, both of which had not been evacuated. Altogether, 165 people were killed across the islands and property damage was estimated at $26 million in 1946 dollars.

November 4, 1952 Kamchatka Tsunami - A magnitude 8.2 earthquake off the Kamchatka Peninsula generated the 1952 tsunami which was felt throughout the Pacific Rim including the Kamchatka Peninsula, the Kuril Islands and other areas of Russia's Far East, Japan, Peru, Chile, New Zealand, Alaska and the Aleutian Islands, and California. The largest waves were recorded in the Hawaiian Islands, outside the generating area. Damage was estimated to reach up to $1 million in 1952 dollars. Boats and piers were destroyed, telephone lines downed, and extensive beach erosion observed.

O'ahu's north shore experienced waves up to 4.5 meters, while on the south shore, the tsunami was powerful enough to throw a cement barge in the Honolulu Harbor into a freighter. On the Island of Hawai'i, tsunami runup reached 6.1 meters, and the bridge connecting Coconut Island in Hilo Bay to the shore was destroyed by a tsunami wave lifting it off its foundation and smashing it down.

March 9, 1957 Aleutian Tsunami - An 8.3 magnitude earthquake off Alaska's Aleutian Islands of Alaska generated the 1957 Pacific-wide tsunami. Property damage in the Hawaiian Islands was estimated at $5 million in 1957 dollars. Waves on the north shore of Kaua'i reached 16 meters, flooding the highway and destroying houses and bridges. At Hilo, Hawai'i, the tsunami runup reached 3.9 meters, damaging buildings along the waterfront and covering Coconut Island with 1 m of water. The bridge connecting it to the shore was again destroyed.

May 22, 1960 Chilean Tsunami - The largest earthquake (magnitude 8.6) of the 20th century occurred off the coast of Chile and generated the 1960 Pacific-wide tsunami. 2,300 people were killed in Chile alone, and more lives were lost throughout the Pacific. 61 people were killed in Hilo, Hawai'i, and property damage there was estimated at more than $500 million in 1960 dollars.

March 28, 1964 Alaska Tsunami – In 1964, a magnitude 8.4 earthquake off Alaska produced a tsunami that affected southeastern Alaska, Vancouver Island (British Columbia), Washington, California and Hawai'i, killing more than 120 people and causing $106 million in damages.

November 29, 1975 Local Hawai'i Tsunami: A 7.2 magnitude earthquake on Hawai'i Island's south coast caused the most recent local tsunami on November 29, 1975. The tsunami was destructive throughout Hawai'i Island.

<u>Historical Tsunami Runup Heights Along the Southern Coast of O'ahu</u>

Tsunami waves can be measured in terms of runup height and inundation. The tsunami inundation limit is the horizontal measure of the maximum inland penetration of the tsunami waves from a certain reference point, such as mean sea level. In other words, the farthest distance inland that tsunami waves traveled. Runup refers to the maximum inland elevation reached by tsunami waves, also generally measured in reference to the mean sea level. Thus, if the reference point is mean sea level, runup is the elevation of the inundation limit.

Interpolations of tsunami runup at the proposed Irradiator site can be made based on reliable runup measurements taken from the coastal areas to the east and west of the Honolulu Airport during the tsunamis of 1946 (Aleutian Islands), 1952 (Kamchatka Peninsula), 1957 (Aleutian Islands), 1960 (Chile), and 1964 (Alaska). As shown in the map below, tsunami runup on south O'ahu shores has reached up to 9 feet, contrary to the incorrect statement made in the CNWRA Report that maximum recorded runup since 1837 is 3 feet.[2]

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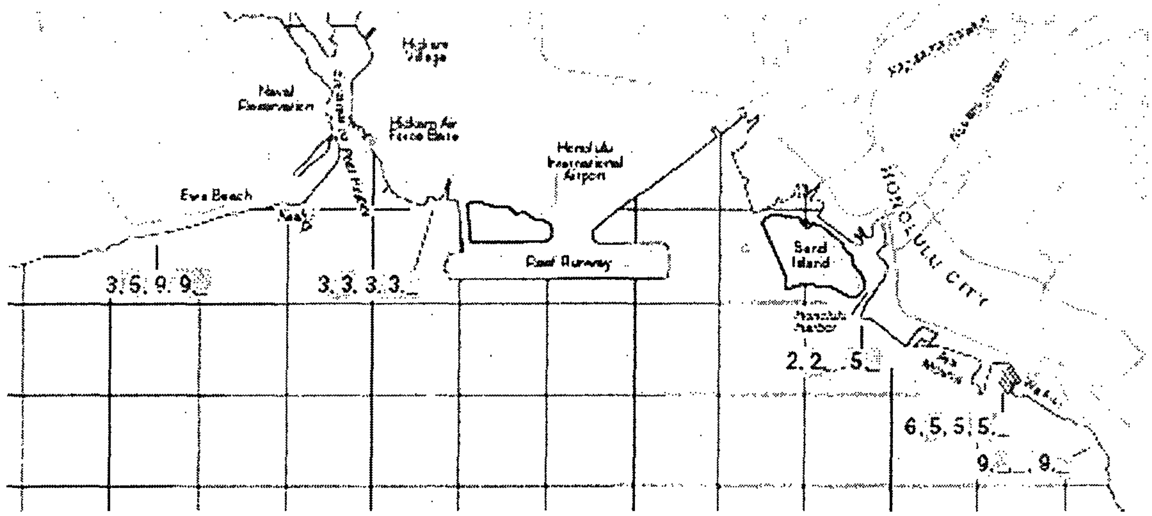
[2] Prior to 1946, Chilean earthquakes generated tsunamis with considerable runups in Honolulu in 1837 (over 8-foot runup), 1868 (over 5-foot runup) and 1877 (almost 5-foot runup) (Pararas-Carayannis, G., and Calebaugh P.J., 1977. Catalog of Tsunamis in Hawaii, Revised and Updated, World Data Center A for Solid Earth Geophysics, NOAA, 78 p., March 1977).



Tsunami Runup in feet for the 1946 (pink), 1952 (red), 1957 (yellow), 1960 (green) and 1964 (blue) tsunamis near the proposed site for the Irradiator.

Because harbors and basins react differently with each tsunami, under the right set of conditions, a tsunami with minimal runup on the open coast results in greater runups and stronger currents within a harbor or semi-enclosed body of water. This can occur when resonance effects excite a basin's natural modes of oscillation, resulting in greater runups and stronger currents. Greater runups can also be generated when certain wave periods combined with certain drainage characteristics of a basin create a cumulative pile-up effect within the basin.

For example, in 1964, the pile-up effect caused extensive flooding and property damage in Port Alberni, Canada, at the head of a 35-mile long inlet on the west coast of Vancouver Island. The first tsunami wave to reach the head of the inlet caused major flooding, but the second wave, which arrived almost an hour later, caused the most destruction. Although the total tsunami energy that entered the inlet was relatively small, a pile-up effect likely caused the second wave to gain force, resulting in greater wave height and runup.

Notably, all the tsunami runup data on which the CNWRA report and DEA rely predate the massive alterations of Ke'ehi Lagoon caused by dredging the lagoon for construction of Honolulu Airport's reef runway, which began in 1973. Dredging deepened Ke'ehi Lagoon, which could increase resonance effects and cumulative pile-up of a tsunami at the apex of the basin, which, incidentally, is at the end of Palekona Street. Only numerical modeling, which neither the CNWRA Report nor the DEA have performed, can reveal the full effects of dredging the lagoon and altering the shoreline.

Tsunami Warnings

Tsunami warnings are issued throughout the state by the Hawai'i Civil Defense based on warnings of the international Pacific Tsunami Warning Center. For tsunamis of distant sources, warnings are issued in Hawai'i about three hours before the tsunami's estimated arrival, although earlier advisories may also be issued. Warnings often stay in effect for several hours before cancellation, because the danger of a tsunami often lies in multiple waves.

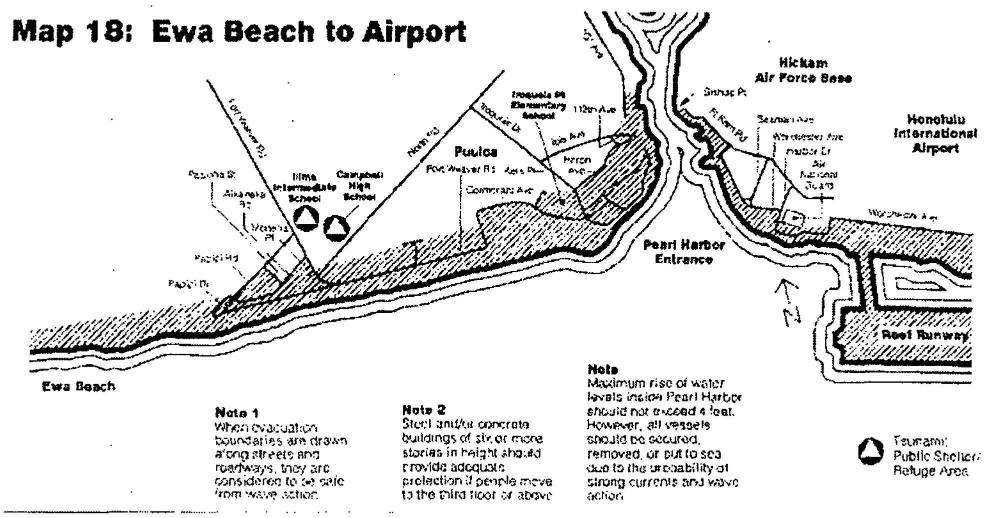
Tsunami Evacuation Areas in the Vicinity of the Proposed Irradiator Site

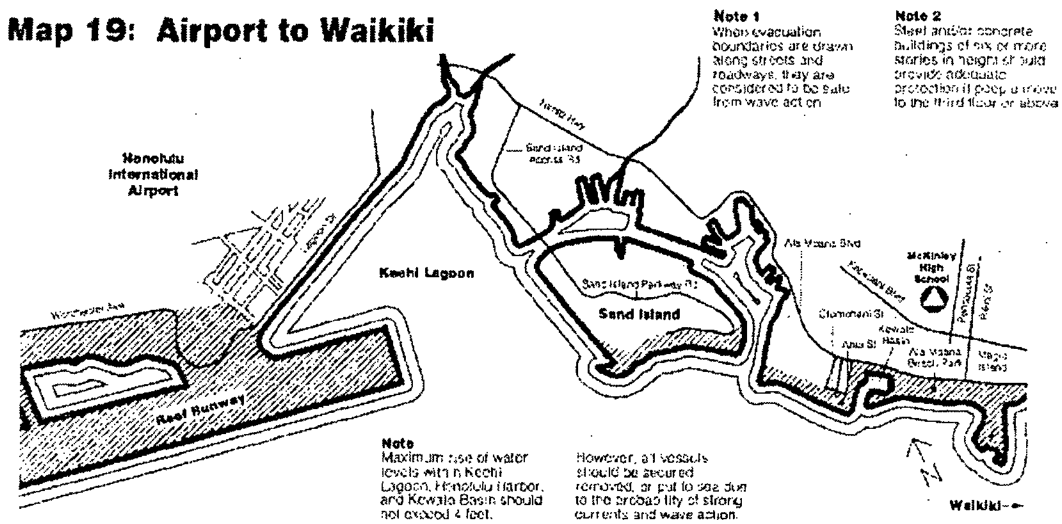
The Hawai'i State Civil Defense requires evacuation of all low lying coastal areas, marked as "tsunami zones" on Civil Defense maps, when tsunami warnings are issued for waves of over 3 feet. When a tsunami warning is issued, the present guidelines recommend evacuating, vertically or horizontally, to a location at least 50 ft above sea level.

Map 19, provided below, indicates that the tsunami evacuation zone currently extends to the 'ewa (west) side of the last street on Lagoon Drive. Because Palekona Street is the last street on Lagoon Drive, and the proposed Irradiator site is on the 'ewa side of Palekona Street, the proposed Irradiator site is within the tsunami zone. Map 18 and 19 also show that the entire reef runway is within the tsunami zone.

Current evacuation maps are based on original maps prepared by the late Prof. Doak Cox and the present reviewer, which relied primarily on historical tsunami data using empirical methods, rather than numerical modeling (Cox & Pararas-Carayannis, 1967). This method tends to underestimate the potential impact of a tsunami, including inundation limits and runups. For example, unusual underwater or shoreline barriers such as reefs, roads, trees, buildings, and other features could focus the tsunami energy so strongly that runups and inundations could far exceed current estimates.

The State Civil Defense, in accordance with the National Tsunami Hazards Mapping Program guidelines, is in the process of updating the current evacuation maps based on accurate numerical modeling of maximum expected tsunami runup values for a given shoreline. The present reviewer is a member of the scientific advisory committee preparing the updated maps.





Tsunami Evacuation Maps from Ewa Beach to Airport, and from Airport to Waikiki (shaded areas indicate potential inundation zones that need to be evacuated horizontally or vertically in solid structures)

Tsunami Risk Assessment for the Proposed Irradiator Site

Due to its low elevation (3-6 feet, depending on tide) and proximity to Ke'ehi Lagoon (375 feet), the proposed Irradiator site is vulnerable to the impacts of a future tsunami, particularly to flooding from the Ke'ehi Lagoon.

Probability of Tsunami Occurrence: Based on the historical record, there is a 100% statistical probability that a major Pacific-wide tsunami will occur again and greatly impact the Hawaiian Islands. The last Pacific-wide tsunami occurred in 1964, and a major tsunami is long overdue. Likely source areas for the generation of major tsunamigenic earthquakes that will affect Hawai'i are the Aleutian Trench, the Gulf of Alaska, and the Chile-Peru Trench.

Potential Tsunami Impact at the Proposed Irradiator Site: The following assessment of the tsunami hazard for the proposed Irradiator site is based on a physical inspection of the site, during which geological conditions; elevation above sea level; distance to the Ke'ehi Lagoon shoreline; background materials submitted with Pa'ina Hawaii's NRC application pertaining to engineering design; photographs; and all available historical tsunami runup data were assessed.

The proposed Irradiator site is relatively flat, with a normal elevation of about 6 feet above mean sea level. During the highest spring tide, elevation is less than 3 feet. The site is 373 feet from the Ke'ehi Lagoon shoreline, and there is no berm or physical barrier between the site and Ke'ehi Lagoon. The Irradiator site is in a tsunami evacuation zone and is near a coastal region that has been inundated by tsunamis in the past.

Due to its low elevation, it is possible that tsunami waves will flood the Irradiator site from the Ke'ehi Lagoon. As previously discussed, a tsunami that generates small runup on the adjacent

open coast can still be damaging within Ke'ehi Lagoon. Resonance caused by the tsunami may excite Ke'ehi Lagoon's natural modes of oscillation, and/or cumulative wave pile-up effects may occur near the head of the Ke'ehi Lagoon basin, either of which would cause greater runup within Ke'ehi Lagoon than the open coast.

Recent numerical studies for the Hawai'i Kai Basin involving tsunami waves of different periods show overtopping of the highway and cumulative effects of runup at the head of the basin.[3] Like the Hawai'i Kai basin, Ke'ehi Lagoon is a semi-enclosed body of water, and under the right conditions, a similar cumulative pile-up effect could occur at the apex of the basin, which is near the proposed Irradiator site. Combined with a high astronomical tide, tsunami waves could overtop the retaining wall at the end of Palekona street and flood the site.

Even without flooding, because of the site's proximity to Ke'ehi Lagoon, a lesser tsunami run-up, superimposed on the ambient water table, could create buoyancy uplift forces on the concrete slab floor and Irradiator platform housing.

Comments on CNWRA Report and EA's Tsunami Analysis

Tsunami Evacuation Limits – The EA and the CNWRA Report both fail to assess or even mention the fact that the proposed Irradiator site is in a tsunami evacuation zone, based on the Civil Defense maps. Also, the CNWRA Report incorrectly states that the O'ahu Civil Defense Agency tsunami flood maps (2006) show the Honolulu International Airport above the tsunami evacuation zone. The Civil Defense maps in fact show that the reef runway and some peripheral airport facilities are within the zone of potential tsunami inundation.

Incorrect Assertion of Tsunami Runup – The CNWRA Report quotes a May 2005 letter from the State of Hawai'i's Department of Transportation, which incorrectly states that "the south shore of O'ahu has never sustained more than a 3 [foot] wave from any tsunami since 1837." Contrary to this assertion, the historic runup record shows that a 1946 tsunami reached a maximum runup on O'ahu's southern coast of 31 feet (Pararas-Carayannis, G., and Calebaugh P.J., 1977, Catalog of Tsunamis in Hawaii, Revised and Updated, World Data Center A for Solid Earth Geophysics, NOAA, p. 78, March 1977). The O'ahu Tsunami Runup Maps show that the 1957 and 1960 tsunamis had maximum runups of 9 feet in east Pearl Harbor. Three Chilean earthquakes generated tsunamis with runup in Honolulu of over 8 feet in 1837, over 5 feet in 1868, and nearly 5 feet in 1877.

Inadequacy of Tsunami Inundation Assessment – The CNWRA Report does not properly consider flooding due to a tsunami. First, the analysis inaccurately relies on tide gauge recordings as evidence of low tsunami runup. Tide gauges filter out short period waves, giving smaller runup heights. Second, the report fails to distinguish between tsunami runup heights (a vertical measurement) with tsunami inundation limits (horizontal measures of inland penetration of a tsunami's waves). In low-lying areas, tsunami inundation can extend inland for several

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[3] Personal communication with Dr. Charles Mader, Los Alamos National Laboratory (LANL). Author provides LANL scientists with tsunami source parameters for tsunami modeling studies. Hawai'i Kai Basin models were prepared to illustrate to the Hawai'i Civil defense the potential vulnerability of the coastline from tsunamis with certain characteristic periods and wavelengths.

hundred yards, even with relatively low runup, depending on the stage of the astronomical tide and the ambient storm wave conditions at the time the tsunami arrives. Third, as explained above, small tsunami run-up height on an open coast does not necessarily mean that the tsunami will not be damaging inside a harbor or within a semi enclosed body of water. The CNWRA Report failed to take into account resonance effects or cumulative pile-up that could occur within Ke'ehi Lagoon and cause higher runup at the proposed Irradiator site than on the open coast. Fourth, runup potential cannot be adequately quantified without a proper numerical modeling study, which CNWRA failed to do. Fifth, the report fails to take into account potential damage from strong currents generated by certain periods of tsunami waves within Ke'ehi Lagoon, which can increase runup.

Irrelevant Assertion of Site Safety Based on the Stylized Fluid Dynamic Calculation - The CNWRA Report's "stylized fluid dynamic calculation" is devoid of any realistic practical value in assessing the potential tsunami hazard or risk to the proposed irradiator site. The calculation does not demonstrate the safety of the site from the potential impacts because it assumes that lifting the source assembly out of the pool is the only danger to the public. It ignores other potential direct impacts and collateral damage, such as failure of peripheral equipment, power and back up generators needed to circulate and cool water in the irradiator pool, leaking of pool water, and dispersal to the surrounding area by potential tsunami flooding, fires from nearby fuel depots, or aircraft or equipment carried and crushing against the irradiator facility, which could affect the integrity of the pool, causing shielding pool water to leak. Reliance on the stylized fluid dynamic calculation further indicates a lack of understanding of a tsunami's terminal characteristics when it moves over land; there is no structured wave form but a chaotic turbulent water mass that cannot be very well correlated to "wave velocity and shear forces necessary to create a vortex inside the pool that would pull a radioactive Co-60 source assembly out of the irradiator pool."

SEISMIC HAZARDS

Historical earthquakes in the Hawaiian Islands are well-documented in the modern (1959–1997) and historic (1868–1959) catalog of the Hawaiian Volcano Observatory. Earthquakes generated within the Moloka'i Fracture Zone and/or the postulated Diamond Head Fault resulted in the upgrade of O'ahu's seismic code from seismic zone 1 to zone 2A.

Historic O'ahu Earthquakes

Earthquakes felt on Oahu generally occur on the Moloka'i Fracture Zone, a seafloor zone of lithospheric weakness south of O'ahu. Two of the largest historical earthquakes, the Lāna'i earthquake of 1871 and the Maui earthquake of 1938 (both about magnitude 7) occurred within the Moloka'i Fracture Zone's complex of ridges and escarpments, which cross the islands south of O'ahu. The 1871 earthquake near Lāna'i caused damage to every building on the Punahou School campus in Honolulu due to an apparent directional focusing of energy. As recently as 27 July 2006 a magnitude 4.5 earthquake occurred 37 km (23 miles) SSW of Mākena, Maui – shaking buildings in Honolulu. In 1948, a magnitude 4.8 earthquake occurred offshore from Honolulu, and caused cracks and other damage in many Honolulu buildings. The 1948 earthquake could have been generated within the Moloka'i Fracture Zone or the postulated

Diamond Head Fault.

Comments on CNWRA Report and EA's Seismic Activities Analysis

Seismic Ground Motions and Potential of Liquefaction - The CNWRA Report improperly trivializes the potential intensity of ground motions and liquefaction potential at the proposed Irradiator site. The Report relies on the assumption that the Modified Mercalli Intensity V estimated for the island of O'ahu for the October 2006 earthquake, which is based on damage reports and observations, also represents the maximum earthquake ground forces that can be expected at the proposed Irradiator site at Honolulu Airport. Unlike magnitude, which represents a single quantity of an earthquake's energy release, intensity does not have one single value for a given earthquake, but can vary significantly from place to place depending on substrata soil conditions. Because the Modified Mercalli Intensity estimate may not have taken into account the properties of unconsolidated sediments, the assumption that maximum ground forces at Honolulu Airport of Intensity V may be incorrect for the proposed Irradiator site. Similarly, the potential horizontal seismic ground motions given in Table 3-1 of the report represent statistical estimates for the southern coast of O'ahu which may not necessarily be valid for the proposed facility site, which is on land reclaimed with unconsolidated sediments.

The Report also fails to consider the potential focusing effects of seismic energy on O'ahu, which can intensify earthquakes with small magnitudes. For example, the 15 October 2006 Hualālai earthquake on O'ahu resulted in relatively high intensity, even though the magnitude was only 6.7 (considerably less than that of 1868 and 1975 earthquakes) and the focal depth was quite deep at 29 km. Unfortunately, it is not known whether any accelerometer readings were taken for this event near Honolulu Airport or elsewhere on the island. Other examples are the 1948 4.6 magnitude earthquake that caused cracks and other minor damage in many Honolulu buildings, and the 1871 earthquake near Lāna'i, which damaged every building on the Punahou School campus in Honolulu. Like the 2006 event, these two historical earthquakes indicate that there is an apparent directional focusing of seismic energy on O'ahu from certain seismic sources which could affect the proposed Irradiator site.

Following an earthquake, ground liquefaction of unconsolidated sediments results primarily from vertical rather than from horizontal ground motions. For example, considerable liquefaction and damage to new buildings occurred in Mexico City during the Great Earthquake of 19 September 1985. Although the epicenter was more than 300 Km away, the valley of Mexico experienced acceleration up to 17% g. with peaks concentrated at 2 sec. period. The extreme damage in Mexico City was attributed to the monochromatic type of seismic wave with this predominant period causing 11 harmonic resonant oscillations of buildings in downtown Mexico City (Pararas-Carayannis, 1985). The ground accelerations were enhanced within a layer of 30 ft. of unconsolidated sediments underneath downtown Mexico City, which had been the site of a lake in the 15th Century, causing many buildings to collapse.

Similarly, the 17 January 1994 Northridge Earthquake had unusually high ground accelerations, even though it had a moment magnitude (Mw) of only 6.7. Extremely strong ground motions - among the strongest ever recorded - occurred in areas in the valley that had thick accumulations of unconsolidated sediments, amplifying the seismic energy and causing extensive damage to the

well-developed metropolitan areas of the San Fernando Valley. Accelerations in the range of 1.0 g and up to 1.78 g were recorded over a large area, and the Modified Mercalli Intensities ranged from VIII to XI (Pararas-Carayannis, 2000). The earthquake was felt over an area of more than 200,000 square kilometers and as far away as 400 kilometers from the epicenter, and landslides and ground failures occurred as far away as 90 kilometers from the epicenter. Extensive ground liquefaction and landslides damaged many structures in San Fernando Valley.

Insufficiency of Load-Bearing Soil Evaluation - The CNWRA Report states that the proposed irradiator pool will be fabricated and installed in accordance with applicable industry codes - but without indicating whether a similar construction of an irradiator has been made elsewhere on reclaimed land that has similar soil conditions. The Report further states that most of the irradiator pool will be below sea level and the load-bearing capability of the soil at the site cannot be evaluated until the pool excavation phase is conducted. Regardless of the soil bearing capacity, there may be a propensity for liquefaction if earthquake ground motions are enhanced due to focusing of seismic waves, particularly if peak ground accelerations exceed 0.20 g.

Conclusions Regarding Safety of Proposed Irradiator at Honolulu International Airport

The DEA and CNWRA Report conclusions that the potential effect of hurricanes, tsunamis, and earthquakes are insignificant are misleading. The site proposed for the construction and operation of the Honolulu Irradiator is clearly marginal and potentially unsafe given its low elevation above sea level, proximity to Ke'ehi Lagoon, and location in the tsunami evacuation zone. The site is particularly vulnerable to potential flooding by future hurricane surges and tsunamis, which could pose environmental risks to public health and safety. Locating the site inland and away from the shores of Keehi Lagoon would eliminate the risk of impacts from tsunami runup and hurricane storm surges.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Pa'ina Hawaii, LLC Materials License Application	)))))	Docket No. 30-36974-ML ASLBP No. 06-843-01-ML

DECLARATION OF METE A. SOZEN, Ph.D. IN SUPPORT OF CONCERNED CITIZENS' CONTENTIONS RE: DRAFT ENVIRONMENTAL ASSESSMENT AND DRAFT TOPICAL REPORT

Under penalty of perjury, I, Dr. Mete A. Sozen, hereby declare that:

1. I am the Purdue University Kettelhut Distinguished Professor of Structural Engineering, and have a Ph.D. in Civil Engineering. I have considerable training and experience in the field of structural engineering, and I have assisted in the development of structural criteria for earthquake and fire resistant building design and helped develop the first set of regulations for earthquake-resistant design. I have been retained by numerous private organizations and state and federal agencies, including the Nuclear Regulatory Commission (NRC), on special projects concerned with structural safety and potential structural damage. A true and correct copy of my resume is attached to this declaration as Exhibit "4.".

2. My research currently focuses on vulnerability assessment of building and transportation structures and effects of explosions and high-velocity impact on building structures. Together with Dr. Christoph Hoffmann, I recently simulated the September

EXHIBIT 6

11, 2001 attacks on the Pentagon and the World Trade Center using LS-DYNA (LSTC2005) code.

3. In conjunction with Dr. Hoffmann, I prepared a numerical analysis, using LS-DYNA (LSTC2005) code, to simulate the potential for damage from an aircraft striking a steel structure adjacent to active runways at the Honolulu International Airport, similar to the proposed Pa'ina irradiator. To prepare this simulation, I reviewed Pa'ina's materials license application and other documents on file in this proceeding, including the Draft Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawaii and the Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Pa'ina Hawaii, LLC Irradiator Facility. The result is a three-dimensional simulation that accurately reflects the physics of the collision. A compact disc containing a true and correct copy of this simulation (which can be viewed using QuickTime software) is attached as Exhibit "5."

4. The use of LS-DYNA to simulate the potential for damage from an aircraft striking a steel structure similar to the proposed Pa'ina irradiator is well-accepted. The NRC has used LS-DYNA antecedents and derivatives in the past to analyze impact effects on various nuclear facilities.

5. The simulation Dr. Hoffmann and I prepared, in my best professional judgment, shows that a disastrous accident could occur in the event of an airplane crashing into a steel structure built adjacent to the Honolulu International Airport, similar to the proposed Pa'ina Hawaii nuclear food irradiator.

6. Because Pa'ina Hawaii failed to provide the building specifications for its proposed irradiator, Dr. Hoffmann and I applied conservative assumptions to create a

model structure that is stronger than what is likely to be achieved in practice. A true and correct copy of the written analysis is attached as Exhibit "6," and describes the modeling in greater detail, including the conservative assumptions built into the analysis. The simulation assumes that the Boeing 767-200ER will crash into the building head on at 100 miles per hour. Since commercial airplanes takeoff and land at much greater speeds, modeling the impact at 100 miles per hour is a credible accident event. Impact of the structure at any angle would produce similar results.

7. The simulation results in acute bending of the columns and the girders, however, because the building was modeled with a toughness that could not be achieved in practice, under actual conditions, many of the columns and girders would fracture or be torn off the connections. Such an impact could directly destroy the building housing the irradiator and the 3 ½ foot lip of the irradiator pool. Destruction of the pool lip could undermine the integrity of the pool, causing the water shielding the Co-60 sources to drain out. A high-temperature conflagration caused by the impact could destroy the pool by melting the steel. Flying debris could breach the source assembly or pool. In all of these instances, radioactive Co-60 could be introduced to the human environment. None of these eventualities was considered by the NRC's draft Environmental Assessment or Topical Safety Report.

8. If Concerned Citizens' contentions are admitted, I would offer additional testimony regarding the opinions set forth herein.

I declare under penalty of perjury that the factual information provided above is true and correct to the best of my knowledge and belief, and that the professional opinions expressed above are based on my best professional judgment.

Executed at West Lafayette, Indiana on this 8th day of February, 2007.

Dr. Mete A. Sozen
Licensed Structural Engineer (Illinois)
Lafayette, Indiana
550 Stadium Mall Drive
West Lafayette, IN 47907-2051
Phone (765) 494-2186
Fax (765) 494-0395

ANALYSIS OF THE EFFECT OF IMPACT BY AN AIRCRAFT ON A STEEL STRUCTURE SIMILAR TO THE PROPOSED PA'INA IRRADIATOR

Mete A. Sozen and Christoph M. Hoffmann[1]

February 1, 2007

Summary

The numerical analysis generated by LS-DYNA (LSTC2005) indicates that a disastrous accident could occur in the event of an airplane crashing into a steel structure built adjacent to the Honolulu International Airport, similar to the proposed Pa'ina Hawaii nuclear food irradiator. Such an accident would create conditions that could lead to introduction of radioactive Cobalt-60 into the human environment. None of these eventualities was considered by the NRC's EA or Safety Report.

Introduction

This report describes a detailed numerical analysis conducted to investigate the potential for damage from an aircraft striking a steel structure adjacent to active runways at the Honolulu International Airport, similar to the proposed Pa'ina irradiator. The analysis involves modeling in finite elements a realistic aircraft and typical industrial building using LS-DYNA computer code. The use of the finite elements results in spatial discretization, allowing powerful computers to solve engineering problems through the application of complex algorithms, with the result in the form of a 3-dimensional simulation that is faithful to the physics of the collision. LS-DYNA antecedents and derivatives are commonly used in the private sector and government laboratories, including the Nuclear Regulatory Commission (NRC), for analyzing impact effects.

The numerical analysis assumes a typical industrial structure and one of the possible combinations of aircraft type and speeds – a Boeing 767, traveling at 100 mph – that could strike such a structure built near active runways at the Honolulu airport. An overall view of the aircraft and the building is shown below in Figure 1.

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[1] Dr. Mete A. Sozen has been the Purdue University Kettelhut Distinguished Professor of Structural Engineering since 1993. He has assisted in the development of structural criteria for earthquake and fire resistant building design and helped develop the first set of regulations for earthquake-resistant design. Dr. Sozen's current research focuses on vulnerability assessment of building and transportation structures and effects of explosions and high-velocity impact on building structures. He has been retained by numerous private organizations and state and federal agencies, including the NRC, on special projects concerned with structural safety.

Dr. Christoph M. Hoffmann has been a Professor of Computer Science at Purdue since 1989 and is currently the Director of Purdue's Rosen Center for Advanced Computing. Dr. Hoffmann recently spearheaded the effort to simulate and visualize the September 11, 2001 attacks on the Pentagon and the World Trade Center applying the same finite element crash analysis used in the present analysis.

Resumes for Drs. Sozen and Hoffmann are attached. Please note that Drs. Sozen and Hoffman have performed this analysis independently; it is not a Purdue University undertaking.

EXHIBIT 7

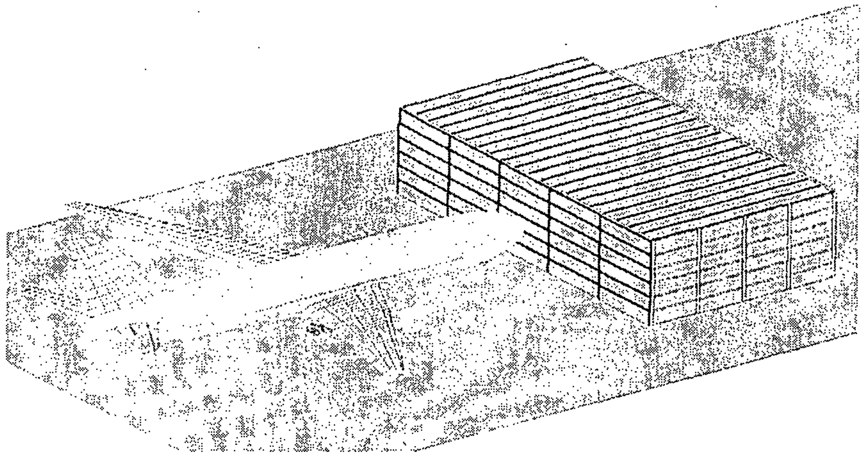

Figure 1. B767 and typical steel industrial structure.

The analysis of the impacts to the structure are considered in reference to the NRC's Draft Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawaii (DEA) and the Draft Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Proposed Pa'ina Hawaii, LLC, Irradiator Facility (Safety Report).

Aircraft Model

The structure of the Boeing 767-200ER aircraft, including dimensions, mass, material, and yield strengths, was modeled in detail based on known aircraft material property information that was obtained from public sources. Figure 2 shows the overall dimensions of the aircraft.

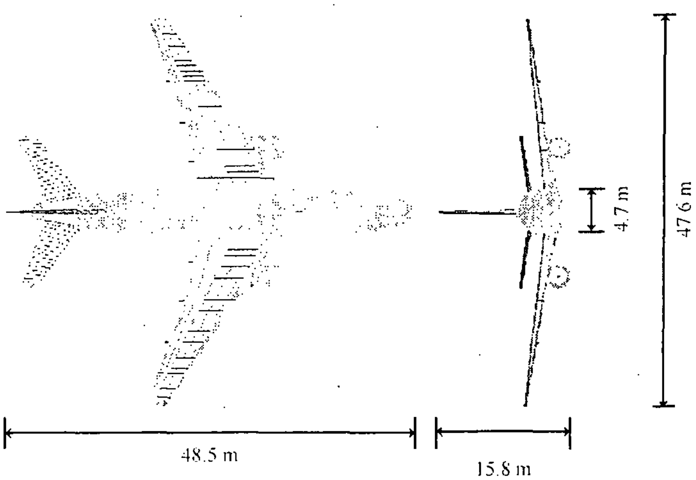

Figure 2. Dimensions of a Boeing 767-200ER.

Approximately 110,000 elements were used to numerically model the solid parts of the aircraft, with a total dry mass of 98 tonnes. The fuel mass totals 30 tonnes and was modeled using approximately 90,000 smoothed particle hydrodynamics (SPH) elements. SPH elements account for the difference in impact effects of solids and fuel. The distribution of the mass along the length of the aircraft is shown in Figure 3.

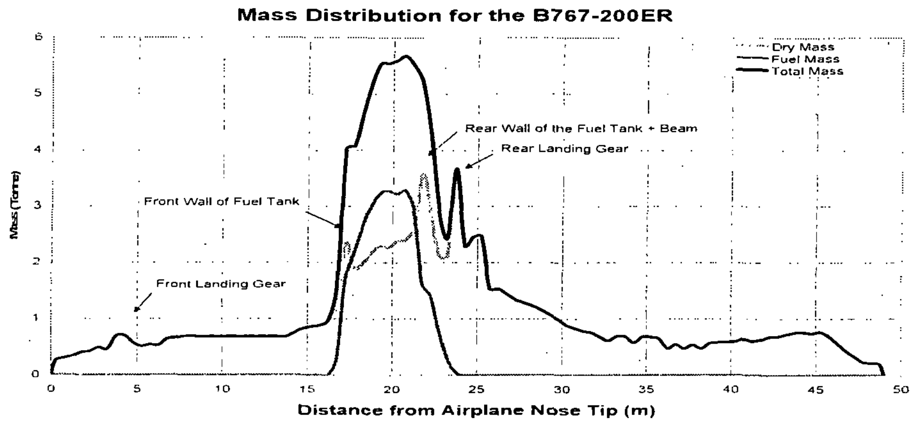

Figure 3. Mass Distribution for a Boeing 767-200ER.

An aluminum material model with yield strength of 380 MPa (55,000 psi) and limiting unit strain of 12% was used for the aluminum parts. For titanium elements, a titanium material model with yield strength of 860 MPa (125,000 psi) and limiting unit strain of 12% was used. Metal sheeting on the surfaces are 3 mm thick and have the same material properties as the main elements.

Structure Model

The structure of the building was modeled as a ductile moment-resisting frame with perfect continuity at the joints and at the bases of the column. Because the actual properties of the building are unknown (due to Pa'ina's failure to provide construction plans), these conservative assumptions were employed to create a model structure that is stronger than what is likely to be achieved in practice. In other words, the proposed irradiator, if built, would suffer greater damage in the modeled aircraft collision than the structure used in this analysis.

Normal specifications were also assumed. The columns (14WF48) and the girders (12WF40) were modeled as structural steel with a normal yield strength of 345 MPa (~50,000 psi) and a limiting unit strain of 40%. Columns were spaced at 24 feet in the long and 16 feet in the short direction of the structure. Height to the roof was set at 30 feet, and the roof girders were spaced at 6 feet. A total of ~210,000 elements were used in the modeling of the building. The framing is shown in Figure 4.

The irradiator pool is modeled as made of a 1/4-inch stainless steel inner tank connected by welded I-beams to a 1/4-inch carbon steel outer tank, with a 42-inch lip extending above the facility floor. The space between the pool's inner and outer steel tanks is modeled as filled with concrete with a yield strength of 4,000 psi.

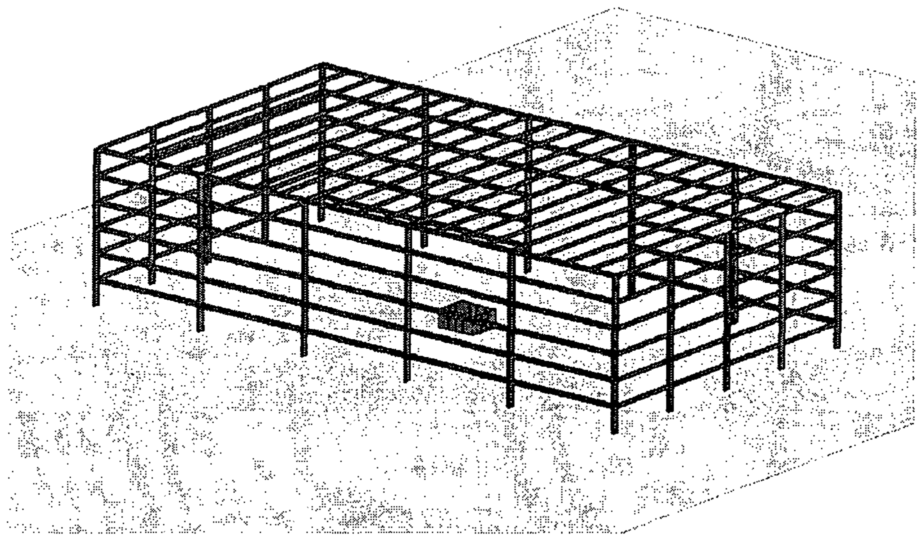

Figure 4. Model framing of steel structure and pool lip.

Impact Simulation Results

Impact simulations were performed using the nonlinear finite-element-based dynamic analysis software LS-DYNA [version 970 r5434a SMP] (LSTC2005) on a multi-processor nano-regatta computer system.

The aircraft was assumed to impact the structure head-on while traveling on the ground at a speed of 100 mph.[2] The "flight path" was assumed to be parallel to the ground and perpendicular to the rear façade of the structure. As depicted in Figure 5, the calculations indicated that the aircraft will crash through the columns and girders of the building. Impact of the structure at any angle would produce similar results.

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[2] 100 mph is a conservative assumption for the aircraft speed, because most aviation crashes occur at landing or take-off, and aircraft generally land and take off at speeds exceeding 100 mph.

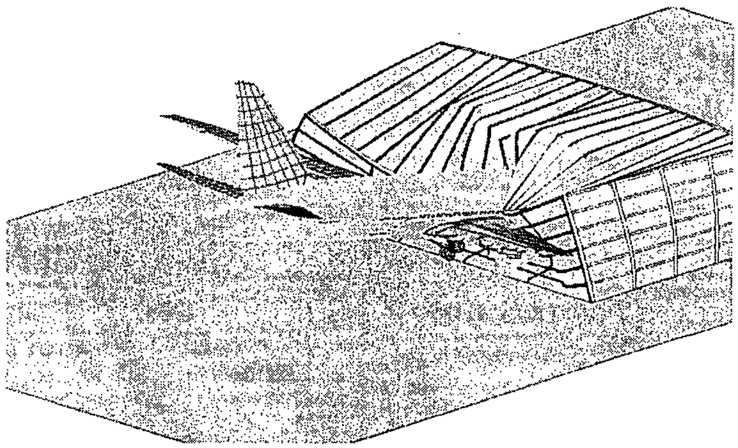

Figure 5. Impact of B767 with steel structure at 100 mph.

Because the building was modeled with a toughness that could not be achieved in practice, this simulation results in acute bending of the columns and the girders, visible in Figure 5. Under actual conditions, many of the columns and girders would fracture or be torn off the connections. Debris and fuel would fill the structure, and the fuel would be expected to ignite explosively, causing a massive conflagration. The total damage within the structure would depend on the existing fire load, including the fuel load and the flammable materials within the building. However, the fire is likely to soften all metals, burn all non-metals, and deteriorate the concrete. This could result in a breach of both the source assemblies and the pool, allowing shielding water to escape. The Co-60 sources could also be exposed if extreme temperatures evaporate the pool water or if the force of the impact disperses the source. In addition, all personnel in the building would likely be killed or incapacitated in the event of a crash and conflagration, and Pa'ina Hawaii's proffered emergency procedures would be rendered useless, because no personnel would be there to implement them.

Chunks of debris, such as engine and landing-gear components, traveling through the building at great speed would likely destroy all equipment, controls, and instrumentation in the building. It is possible that debris could enter the pool and breach the radioactive sources. Debris may directly impact the sources or cause heavy equipment held in place above the pool to snap, fall into the pool, and strike the source assemblies, resulting in dispersal of radioactive material.

The "very strong forces" that the source assemblies will have been tested against, according to the Safety Report, will not stand up to the forces of an airplane crash. For example, the mass and velocity of falling debris will deliver much more destructive energy than the NRC impact standard for source assemblies, which is a 2-kg steel weight falling from a height of 1 meter.

The lip of the irradiator pool, which extends 3 ½ feet above the floor, will likely buckle under the impact of an aviation crash, despite a 6-inch layer of reinforced concrete between two ¼ inch metal shells. Further, because the pool's inner and outer steel layers are likely connected with welded I-beams, which do not perform well under extreme impact, the shock of the impact could affect the welds and cause the pool to breach, allowing the water to drain out.

Conclusion

The preceding analysis leads to the conclusion that the effects of a plane crash on an industrial building housing a nuclear irradiator would be devastating. Because the modeled steel structure is more robust and more tenacious than what Pa'ina Hawaii is likely to build, the effects in reality are likely to be greater than the modeled effects. Such an impact could directly destroy the building housing the irradiator and the 3 ½ foot lip of the irradiator pool. Destruction of the pool lip could undermine the integrity of the pool, causing the water shielding the Co-60 sources to drain out. A high-temperature conflagration caused by the impact could destroy the pool by melting the steel. Flying debris could breach the source assembly or pool. In all of these instances, a plane crash would create conditions that could lead to introduction of radioactive Cobalt-60 into the human environment. None of these eventualities was considered by the NRC's EA or Safety Report.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Pa'ina Hawaii, LLC Materials License Application	)))))	Docket No. 30-36974-ML ASLBP No. 06-843-01-ML

DECLARATION OF MARVIN RESNIKOFF, Ph.D.
IN SUPPORT OF CONCERNED CITIZENS'
CONTENTIONS RE: FINAL ENVIRONMENTAL ASSESSMENT

Under penalty of perjury, I, Dr. Marvin Resnikoff, hereby declare that:

1. I am a physicist with a Ph.D. in high-energy theoretical physics from the University of Michigan and also the Senior Associate of Radioactive Waste Management Associates, a private technical consulting firm based in New York City. I previously filed declarations in support of Concerned Citizens of Honolulu's Request for Hearing and Concerned Citizens' Contentions Re: Draft Environmental Assessment And Draft Topical Report. My credentials to discuss risk assessment and other technical issues related to Pa'ina Hawaii, LLC's proposed irradiator were previously stated in my prior declarations and will not be repeated here.

2. I have reviewed the Final Environmental Assessment Related to the Proposed Pa'ina Hawaii, LLC Underwater Irradiator in Honolulu, Hawaii ("Final EA") (ADAMS Accession No..ML071150121), the Final Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Pa'ina Hawaii, LLC Irradiator Facility ("Final Topical Report") (ADAMS Accession No. ML071280833), and other documents from the hearing file.

EXHIBIT 8

3. In my February 9, 2007 declaration in support of Concerned Citizens' Contentions Re: Draft Environmental Assessment And Draft Topical Report, I discussed the many flaws in the draft Topical Report's analyses of the likelihood and consequences of an aircraft crashing into Pa'ina's proposed irradiator and of the threat of radiation exposure in the event of an aviation accident or natural disaster. I explained that, because the draft EA relies on the draft Topical Report's flawed analysis, its discussion of potential environmental impacts associated with Pa'ina's proposed irradiator is likewise lacking, failing to take into consideration potentially significant impacts to public health and safety and to the environment from aviation accidents and natural disasters. In addition, I noted the draft EA's omission of any analysis of potential impacts associated with terrorist attacks on the irradiator or on Co-60 sources being transported to or from the irradiator and the lack of any consideration of transportation accidents involving such sources. Finally, I explained that, since the reason for the high probability of an aircraft impact is the proximity of the proposed facility to active runways at Honolulu International Airport, the Nuclear Regulatory Commission (NRC) should have evaluated alternate locations for the irradiator, far from the airport, which would substantially reduce risks to the public associated with aviation accidents.

4. The Final EA and Final Topical Report contain few material changes from the draft versions of these documents, and, accordingly, for the most part, the same fatal flaws identified in my earlier declaration remain. In this declaration, I focus on the few instances where the discussion in the Final EA (or in the Final Topical Report, which the Final EA references) differs significantly from the information and analysis presented in the draft. As discussed in detail below, the Final EA fails to take a hard look at

potentially significant impacts to the human environment associated with Pa'ina's proposed irradiator and to consider reasonable alternatives that would accomplish the project's goals with less environmental harm.

5. **Probability of Aircraft Impact into Proposed Pa'ina Irradiator.** The Final EA incorporates by reference the Final Topical Report's analysis of the likelihood of an aircraft striking Pa'ina's proposed irradiator. The Final Topical Report, however, perpetuates the flaws in the draft Topical Report, resulting in an underestimate of the probability of a crash by a factor of 2 to 3, as discussed in my February 9, 2007 declaration and attached report.

6. While the Final Topical Report attempts to show how its 1 in 5,000 aircraft crash probability was overestimated, it continues to ignore significant factors that cut the other way. For example, the Final Topical Report continues to rely on obsolete data and fails to account for unusually elevated crash rates at Honolulu International Airport and the higher proportion of crashes at landings than takeoffs. Moreover, the Final Topical Report continues to use an unreasonably low number of aircraft operations at the Honolulu airport (apparently relying on a five-year average that includes the sharply reduced operations in the years following September 11, 2001) and fails to factor in the projected 20% increase in operations during the ten-year term of Pa'ina's license. As explained in my February 9, 2007 declaration, properly addressing these important factors results in a substantially higher crash probability estimate. Because the Final Topical Report's analysis is not based on an accurate assessment of the likelihood an airplane will hit the facility, the Final EA's reliance on that flawed analysis precludes the NRC from taking the requisite hard look at potentially significant impacts.

7. **Consequences of Aircraft Impact into Pa'ina Irradiator.** Like the draft. the Final EA fails to substantiate with any calculations its assumption the performance criteria set forth in 10 C.F.R. § 36.21 would ensure Co-60 sources at the Pa'ina irradiator survive an aviation accident without being breached. Instead of quantifying the impact of flying aircraft or building debris on the Co-60 sources and evaluating the likelihood radioactive material would be dispersed, the Final EA merely asserts baldly that it is "unlikely that a Co-60 sealed source would be breached in the event that an aircraft crashes in to the proposed facility." The assumption that a release is unlikely lacks any scientific support.

8. Moreover, even if a release of radioactive material were, in fact, "unlikely," that does not mean it is impossible. The Final EA fails to analyze the potentially significant consequences to public health and safety and the environment in the event a release does occur.

9. The Final EA inaccurately assumes the irradiator pool water could become contaminated only if the Co-60 slug were allowed to corrode in the water following a breach in the source encapsulation. The analysis ignores the potential for physical destruction of the sources to contaminate the pool water or allow dispersal of pulverized Co-60 via breaches in the pool lining.

10. The Final Topical Report, on whose analysis the Final EA relies, states that Co-60 sources provided by Nordion would, in addition to complying with 10 C.F.R. § 36.21, also have passed ANSI test E65646. However, the Final Topical Report lacks any calculations to back up its assertion that sources that pass ANSI test E65646 would

be adequate to prevent dispersal of radioactive material in the event of an aviation accident. Thus, the requisite safety showing has not been made.

11. The Final EA slightly improves on the draft in that it concedes an aviation crash would likely cause a jet fuel fire at Pa'ina's proposed irradiator. The few lines devoted to the topic are, however, rife with unsubstantiated assumptions that preclude reliance on its analysis to evaluate the potential for significant impacts. The Final EA initially assumes burning jet fuel will not come into contact with the sources, ignoring the potential for an aviation accident to breach the irradiator pool, allowing shielding water to escape. Then, without any calculations about rates of evaporation or the length of time a fuel fire would be expected to burn, the Final EA baldly asserts there would be "minimal water evaporation." This is pure speculation.

12. The Final EA's ultimate conclusion that burning jet fuel would not cause potentially significant environmental impacts is likewise unsupported by either calculations or empirical data. Implicitly acknowledging the Final Topical Report erred in asserting jet fuel burns at only up to 599 °F (315 °C), the Final EA notes instead that jet fuel burns at an average temperature of 1,814 °F (990 °C). This is far in excess of the 1,112 °F (600 °C) temperature that sources must withstand under 10 C.F.R. § 36.21(b) and the 1,475 °F (802 °C) temperature under ANSI test E65646. The Final EA fails to substantiate its claim that the inferno associated with an aviation crash could not breach the Co-60 sources, creating the potential for radiation releases. The maximum (adiabatic) flame temperature for jet fuel is greater than 3100 ^{o}F, while the melting point of cobalt is 2,723 °F. This indicates that, in addition to the source cladding, the cobalt itself has the possibility of melting.

13. The Final EA also improperly downplays the consequences of a loss of shielding water due to an airplane crash, which threatens exposures above regulatory limits. Using the proprietary program Microshield, the final EA states (on page 9) that a loss of six feet of pool water would result in a dose of 300 millirems/hr. The EA, however, provides no justification for calculations that assume a loss of only six feet of shielding water. According to the Final Topical Report (at page 1-2), the depth of the water table is 2.4 meters (8 feet) below the facility floor. Since a rupture of the pool lining in the event of an accident or natural disaster could cause shielding water to drain to the groundwater level, the EA should have performed its dose calculation assuming an 8-foot drop in water level. My calculations, attached as Exhibit 10, show that the dose at floor level would be greater than 14 rem/hr.

14. In cases in which more shielding water were removed from the irradiator pool, either from the force of an explosion or through evaporation in a fuel fire, radiation doses would be far higher. If all water were removed from the irradiator pool, my calculations show that the likely dose would be over 107,000 rems/hr Emergency personnel could receive an LD50 dose in less than one minute.

15. Whether the water level fell to groundwater level or the irradiator pool were completely dry, emergency responders and irradiator personnel could be seriously injured from radiation exposure.

16. **Transportation Accident.** Using Radtran 5.3, the EA calculates transportation impacts from normal operations and determines these would be small (p. 8). The incident-free impacts considered by the EA involve only normal on the ground impacts. The Staff do not consider normal impacts from transportation on the ground to

the foreign airport, in Canada or Russia, and do not consider the impacts of an accident during flight. Transportation casks are designed for a 30-foot drop onto an unyielding surface and planes obviously fly higher than 30 feet. The environmental impact of an aircraft accident while transporting a cask containing Co-60 pencils should be considered. Transportation impacts are considered for reactor licensing proceedings in which licensees use Table S-4 to assess transporting spent fuel from the reactor site; a similar analysis and Table must be developed for the proposed irradiator.

17. Finally, the Final EA has no basis for dismissing the potential for significant impacts in the event an airplane crash destroys all monitoring equipment and/or incapacitates irradiator personnel. Even if, as the Final EA asserts, the loss of operating monitoring equipment during an accident did not lead to the loss of control of radioactive material, the inability to implement necessary emergency procedures threatens to put first responders and the general public in harm's way. The Final EA fails to evaluate such potential consequences.

18. **Terrorist Attacks on Irradiator.** Unlike the draft, the Final EA includes in Appendix B a discussion of terrorist attacks on Pa'ina's proposed irradiator. The discussion is, however, woefully inadequate to assess the specific threats terrorist attacks pose to the Pa'ina irradiator, the facility's vulnerability to such attacks, and the foreseeable consequences in the event of an attack.

19. Included in Exhibit "2" and incorporated herein by reference is a report I prepared on July 6, 2007 to analyze the vulnerability and potential consequences of a terrorist attack on Pa'ina's proposed irradiator. The report demonstrates the Final EA could have thoroughly analyzed the threats, vulnerability, and potential consequences of

an attack. Such an analysis is necessary allow the NRC to make an informed decision about the risk and potential significance of a terrorist attack on Pa'ina's irradiator.

20. Like the Final EA, my report assumes that a general credible threat of a terrorist attack exists. Under International Atomic Energy Agency (IAEA) guidance, the Pa'ina irradiator, which would be licensed to possess up to one-million curies of Co-60, would be classified as a Category 1 radioactive source. According to the IAEA, Category 1 sources are "considered to be the most 'dangerous' because they can pose a very high risk to human health if not managed safely and securely."

21. To determine the vulnerability of Pa'ina's proposed irradiator, I considered three plausible scenarios involving a determined sabotage group. Scenario one assumed the saboteurs dropped an M3A1 shaped charge to the bottom of the irradiator pool. Scenario two assumed the saboteurs would have the use of a TOW2 or MILAN anti-tank missile. Scenario three assumed the saboteurs would crash a Boeing 757 into the building at greater than 100 mph. This is a conservative assumption because, under normal conditions, B757's take-off and land at about 180 mph. The plausibility is even greater given Pa'ina's proposal to locate its irradiator next to the runways of the Honolulu International Airport.

22. As detailed in the report, the irradiator pool and sources are vulnerable to terrorist attack. In scenario one, an M3A1 shaped charge could easily punch a hole into the side of the pool, likely expelling all the water from the pool and/or allowing all the water to drain from the pool. For scenario two, the force from the TOW2 or MILAN anti-tank missile could punch a hole through the side of the pool. Scenario three demonstrated that the shaft of a Rolls Royce jet engine could puncture the pool wall.

23. In any of these three scenarios, following puncture of the pool lining, a party of saboteurs could ignite a combustible material or detonate explosives inside the pool, which could, in turn, blast apart or aerosolize the Co-60 pellets at the bottom of the pool, resulting in dispersal of radioactive particulates into the surrounding environment.

24. A radiological release would contaminate the surrounding area, including the Honolulu International Airport and Ke'ehi Lagoon. A 2002 report of the Federation of American Scientists – which was attached to my February 9, 2007 declaration – showed detonation of just one Co-60 pencil (about 17,000 curies) at the lower tip of Manhattan would contaminate approximately 1,000 square kilometers, exposing tens of thousands of residents to high-levels of radiation. If the radiation could not be immediately removed, large portions of New York City would be uninhabitable for decades while the Co-60 decayed and/or buildings would need to be demolished. According to the report, the risk of death from cancer would jump to one-in-ten for people who live in an area of about three hundred city blocks.

25. Even if it were possible to remove the radiation in the event Co-60 was detonated at the proposed Pa'ina irradiator, such a cleanup could shut down the runways of the Honolulu International Airport for weeks. A closure of vital runways could seriously hurt Hawai'i's economy, which depends on air shipments for food, goods, and mail service, and could also disrupt Hawai'i's main economic engine, tourism. Moreover, any of these scenarios could immediately kill on-duty irradiator employees, emergency responders, and any other person in the general vicinity, which is easily accessible by the public. Also, whether successful in dispersing Co-60 or not, a terrorist act at the proposed irradiator would likely cause widespread panic and fear, which could

adversely affect the morale and well-being of the people of Hawai'i and cause a decline in tourism. The Final EA fails to assess the significance of any of these possible impacts.

26. Other plausible modes of attack that the Final EA should have considered, but did not, include the potential for terrorists to divert the Cobalt-60 sources during transport to or from the facility or the theft of the sources from the irradiator facility itself. The radioactive materials could then be coupled with an explosive charge or placed in heavily populated locations, exposing the public to unacceptable levels of radioactivity.

I declare under penalty of perjury that the factual information provided above is true and correct to the best of my knowledge and belief, and that the professional opinions expressed above are based on my best professional judgment.

Executed at New York, New York on this 24th day of August, 2007.

Dr. Marvin Resnikoff, Senior Associate
Radioactive Waste Management
526 West 26th Street, Room 517
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Line Source

$$\phi = \frac{S}{4\pi h} 2\theta$$

$$\tan(\theta) = \left(\frac{L/2}{h}\right)$$

S L=	7.8E+16	photons/sec
φ =	4.9058E+10	photons/cm2/s
	6.1323E+10	MeV/cm2/sec
	107315.27	R/h at bldg flr

where h is distance pool floor to bldg floor
L is width of plenum (cm)
S is photons/sec/cm
φ is photon flux (photons/cm2/sec)

Point Source

$$R \cong 0.53CEn$$

C=# Ci
E energy (MeV)

R/h at 1 m

distance pool floor to bldg floor	18.50	ft
top plenum 82"	6.83	ft
water shield, pool filled	11.67	ft
water shield, 6' water drop	5.67	ft
water shield, 8' water drop	3.67	ft
water shield, 6' water drop	172.82	cm
water shield, 8' water drop	111.86	cm

104723.52 R/h at bldg flr

EXHIBIT 10

Gamma Attenuation

$$I = bI_0 e^{-\mu x}$$

where b = buildup factor

I_o = initial gamma flux

μ = linear attenuation coefficient

x = absorber thickness

I_6= attenuation 6' water shield

I_8= attenuation 8' water shield

$$I_8 / I_6 = \left(\frac{b_8}{b_6} \right) e\left[\mu(x_6 - x_8) \right]$$

μ=6.323E-2 cm2/g		6.32E-02
		1.09E+01
$\left(\frac{b_8}{b_6} \right)$	0.605364	7.07E+00
	3.85E+00	
I_8 / I_6	47.21	
	14.16	R/h at bldg flr

CERTIFICATE OF SERVICE

The undersigned hereby certifies that, on September 14, 2007, a true and correct copy of the foregoing document was duly served on the following via e-mail and first-class United States mail, postage prepaid:

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Dated at Honolulu, Hawai'i, September 14, 2007.

DAVID L. HENKIN
Attorneys for Intervenor
Concerned Citizens of Honolulu

EARTHJUSTICE
Because the earth needs a good lawyer

BOZEMAN, MONTANA DENVER, COLORADO HONOLULU, HAWAI'I
INTERNATIONAL JUNEAU, ALASKA OAKLAND, CALIFORNIA
SEATTLE, WASHINGTON TALLAHASSEE, FLORIDA WASHINGTON, D.C.

TRANSMITTAL LETTER

TO: Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Rulemakings and Adjudications Staff

VIA FIRST CLASS MAIL

FROM: David L. Henkin

DATE: September 14, 2007

RE: Pa'ina Hawaii, LLC (Materials License Application),
Docket No. 30-36974-ML, ASLBP No. 06-843-01-ML

ENCLOSURES	DATE	DESCRIPTION
Original and two copies:	9/14/07	INTERVENOR CONCERNED CITIZENS OF HONOLULU'S CONTENTIONS RE: FINAL SAFETY EVALUATION REPORT; DECLARATION OF DAVID L. HENKIN; DECLARATION OF GEORGE PARARAS-CARAYANNIS, PH.D.; EXHIBITS "1" – "8;" CERTIFICATE OF SERVICE

[ ] For Your Information.
[ ] For Your Files.
[ ] Per Our Conversation.
[ ] Per Your Request.
[ ] For Review and Comments.
[ ] See Remarks Below.

[X] For Filing.
[ ] For Recordation.
[ ] For Signature & Return.
[ ] For Necessary Action.
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