

NRCREP - Docket No. 030-36974

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Subject: Docket No. 030-36974
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Please find attached Concerned Citizens of Honolulu's comments for Docket No. 030-36974, regarding Appendix B, the supplemental terrorism analysis for the Pa'ina Hawaii irradiator Environmental Assessment. A hard copy will follow by mail. Please do not hesitate to contact me with any questions. Thank you, Koa Kaulukukui

<<7-9-07 let to NRC re App B.pdf>>

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Re: Docket No. 030-36974
Appendix B: Consideration of Terrorist Attacks on the Proposed Pa'ina Irradiator
(Supplement to Draft Environmental Assessment and Finding of No Significant
Impact for Proposed Pa'ina Hawaii, LLC Irradiator in Honolulu, Hawaii)

To Whom It May Concern:

Earthjustice submits these comments on behalf of Concerned Citizens of Honolulu in response to the Nuclear Regulatory Commission's ("NRC's") June 8, 2007 request for comment on the supplement to its Draft Environmental Assessment and Finding of No Significant Impact for Proposed Pa'ina Hawaii, LLC Irradiator in Honolulu, Hawaii ("Draft EA") addressing terrorist acts involving the proposed irradiator ("Appendix B"). See 72 Fed. Reg. 31,866 (June 8, 2007). The NRC Staff prepared both the Draft EA and Appendix B in response to objections Concerned Citizens raised to Pa'ina's application to place up to one million curies of radioactive Cobalt-60 in an irradiator proposed to be built next to active runways at the Honolulu International Airport. Regrettably, Appendix B fails to satisfy the NRC's obligations under the National Environmental Policy Act ("NEPA") to provide a serious, scientifically-based analysis of the risk of terrorist acts involving Pa'ina's proposed irradiator and of all reasonably foreseeable impacts of such acts. In preparing these comments, Earthjustice was assisted by Dr. Marvin Resnikoff, who prepared an Analysis of the Vulnerability and Potential Consequences of a Terrorist Attack on the Proposed Pa'ina Hawaii Irradiator ("Resnikoff Report"), which critiques Appendix B and is enclosed and incorporated herein by reference. In addition, we relied on the declaration from Dr. Gordon Thompson regarding the risk of terrorist attack, which was enclosed in Earthjustice's February 8, 2007 comments on the Draft EA and is also incorporated herein by reference.

Failure to determine the risk of a terrorist attack on the Pa'ina irradiator

The Staff admits "there is a general, credible threat to NRC-licensed facilities and materials" from terrorist attacks and acknowledges it is necessary and "possible to assign qualitative probabilities to [such attacks]." Appendix B at B-4. The EA even describes two

methods the NRC uses to assess the threat of terrorist attacks on nuclear facilities: (1) the Threat Advisory System, and (2) the "security assessment framework," which the NRC uses to determine whether to step-up security for nuclear facilities. The Staff clearly has the ability to determine the risk of a terrorist attack on particular irradiators and apparently has done so in the past, yet it inexplicably failed to apply these methods, or any other, to determine the likelihood, quantitatively or qualitatively, of a terrorist attack on Pa'ina's proposed irradiator.

First, Appendix B fails to provide any quantitative analysis of the likelihood Pa'ina's proposed irradiator would be the target of a terrorist attack and, thus, fails to take the "hard look" at terrorist-related impacts that NEPA requires. Klamath-Siskiyou Wilderness Center v. Bureau of Land Management, 387 F.3d 989, 1001 (9th Cir. 2004). "General statements about possible effects and some risk" like those found in Appendix B "do not constitute a hard look absent a justification regarding why more definitive information could not be provided." Id. at 994 (quoting Neighbors of Cuddy Mountain v. United States Forest Service, 137 F.3d 1372, 1380 (9th Cir. 1998)). If it is possible to quantify impacts from terrorism objectively, NEPA requires that the Staff do so. Id. As the Ninth Circuit stressed in San Luis Obispo Mothers for Peace, the existence of probabilistic risk assessments of terrorist activities by the Department of Homeland Security and others casts serious doubts on any claim the "risk of terrorism cannot be quantified." San Luis Obispo Mothers for Peace v. Nuclear Regulatory Comm'n, 449 F.3d 1016, 1032 n.9 (9th Cir. 2006), cert. denied sub nom, Pacific Gas & Elec. Co. v. San Luis Obispo Mothers for Peace, 127 S. Ct. 1124 (2007).

Second, even if "the numeric probability of a specific attack" cannot be quantified, the NRC must still "assess likely modes of attack, weapons, and vulnerabilities of the facility, and the possible impact of each of these on the physical environment, including the assessment of various release scenarios." Id. at 1031 (emphasis added). Thus, the Staff was required to analyze in Appendix B the vulnerabilities of the particular irradiator facility Pa'ina proposes, as well as its location and plausible threat scenarios. It failed to do so, as discussed below.

Taking a hard look at the physical vulnerability of the site is an important step in determining the likelihood of a terrorist attack involving the proposed irradiator. See, e.g., San Luis Obispo Mothers for Peace, 449 F.3d at 1031 (NRC must "assess . . . vulnerabilities of the facility"). The Staff cannot rely on a general discussion of security assessments it has undertaken for other facilities in the past or on Appendix B's bare assertion that the irradiator and the sources are too robust to succumb to terrorist sabotage. It can and must provide hard data, such as calculations or modeling, as well as appropriate standards against which to compare the results of its analysis, to ascertain whether Pa'ina's irradiator would be vulnerable to terrorist attack. See Klamath-Siskiyou Wilderness Center, 387 F.3d at 994.

For example, as discussed in Dr. Resnikoff's report, data show that a Milan anti-tank missile could easily penetrate 4 feet of concrete and 1 meter of steel, a structure much more robust than the ½ inch of stainless steel and 6 inches of concrete in Pa'ina's irradiator design. See Resnikoff Report at 3. Dr. Resnikoff's analysis calls into question the Staff's contrary assumption the sources would be safe from terrorist attack because they can withstand the impact

of a 4.5 pound weight falling from 3 feet. Moreover, the Staff's analysis is unsupported by any data and, thus, inadequate to satisfy NEPA.

Assessing the risk of a terrorist attack on the Pa'ina irradiator also requires consideration of specific features of the proposed irradiator site and its surroundings that make the irradiator particularly vulnerable to terrorist attack. This assessment must include, among other things, factors the NRC has previously identified as relevant to its security assessments: "iconic value, complexity of planning required, resources needed, execution risk, and public protective measures." Appendix B at B-5. In the case of Pa'ina's proposed irradiator, the Staff must consider the following factors, which individually or combined make the irradiator particularly attractive to terrorists and vulnerable to attack:

- Pa'ina proposes to place its irradiator directly adjacent to the runways of the Honolulu International Airport, the economic lifeline of the State of Hawai'i.
- The proposed irradiator site is near to an internationally symbolic icon, Pearl Harbor.
- The proposed irradiator would be next to numerous other military bases, including Hickam Air Force Base, which shares runways with Honolulu International Airport.
- The applicant proposes to use Cobalt-60, a prime source material for dirty bombers.
- The applicant proposes to use up to one million curies of Cobalt-60, an amount many orders of magnitude greater than the "quantity of concern" of 8.1 curies the NRC has established as triggering the need for additional security measures. 70 Fed. Reg. 72,128, 72,132 (Dec. 1, 2005).
- Terrorists could easily gain access to the Pa'ina irradiator, which would be located at the end of Lagoon Drive, a road that is open to the public and lacks any controls on access, and adjacent to Ke'ehi Lagoon, allowing unrestricted access via the water.

Finally, an assessment of the risk of attack requires consideration of plausible threat scenarios, or the "likely modes of attack." San Luis Obispo Mothers for Peace, 449 F.3d at 1031. Appendix B completely fails, however, to analyze any of the likely modes of attack, including threat scenarios to which Pa'ina's proposed irradiator would be particularly vulnerable.¹ For example, the use of an aircraft as a mode of attack is especially plausible at the proposed irradiator site, given Pa'ina proposes to place the irradiator immediately next to active runways at the Honolulu International Airport. See Resnikoff Report at 2. Moreover, given the unrestricted access to Pa'ina's irradiator site and the iconic and strategic value of surrounding targets, it is plausible that terrorists would force their way into the facility, hoist the sources out

¹ The Staff asserts it "evaluated a spectrum of threat scenarios" as a part of its generic "security assessment framework." Appendix B at B-5. This generic analysis is not enough to satisfy NEPA, which requires the NRC to take a hard look at potential impacts from the specific action under consideration: licensing of Pa'ina's proposed irradiator. Moreover, Appendix B fails to discuss which scenarios were considered and how these scenarios were screened for "plausibility." Id.; see also Klamath-Siskiyou Wildlands Center, 387 F.3d at 996 (it is well-established that "NEPA documents are inadequate if they contain only narratives of expert opinions").

of the irradiator pool, affix explosives to them, and detonate a "dirty bomb" in the heart of the airport and urban Honolulu. Nowhere in Appendix B is there any discussion of the potential for such attacks or their consequences.

To allow the NRC to assess the likelihood of a terrorist attack, the Staff was obliged to provide in Appendix B either a quantitative probability or a qualitative risk analysis, including: (1) hard data regarding the physical vulnerability of the proposed irradiator, (2) analysis of the specific features that make the irradiator and its environs susceptible to attack, and (3) an assessment of the likely modes of attack on the Pa'ina irradiator. Appendix B unlawfully fails to address any of these fundamental elements, precluding the informed consideration of the significance of potential effects that NEPA requires. See 40 C.F.R. § 1500.1(b) (NEPA mandates that "environmental information is available to public officials and citizens before decisions are made and before actions are taken").²

Failure to disclose data supporting the finding of no significant impact

Because public scrutiny of an agency's analysis is vital to accomplishing NEPA's goals, "NEPA requires that the public receive the underlying environmental data from which [the Staff] derived [their] opinion[s]." Idaho Sporting Cong. v. Thomas, 137 F.3d 1146, 1150 (9th Cir. 1998). This "information must be of high quality," 40 C.F.R. § 1500.1(b), and the NRC must "identify any methodologies used" and "insure the professional integrity, including scientific integrity, of the discussions and analyses" in its NEPA documents, id. § 1502.24. Because "[t]he reader is not told what data the conclusion [that terrorism-related impacts are insignificant] was based on or why objective data cannot be provided," Appendix B is inadequate. Klamath-Siskiyou Wildlands Center, 387 F.3d at 994.

Information Appendix B must provide the public pursuant to the above principles include:

- Data regarding generic security assessments. In concluding that "radiological sabotage of the proposed irradiator is expected to result in generally small radiological consequences[,] the Staff relies on generic "security assessments" for irradiator facilities. Appendix B at B-6. Appendix B fails to provide any discussion of the aspects of these generic security assessments the Staff concluded were relevant to its analysis.

² Despite failing to undertake any analysis of the probability of a terrorist attack on the Pa'ina irradiator, the Staff asserts protective measures will lower that risk to an "acceptable level." Appendix B at B-7. With no baseline risk analysis, the Staff has no basis to conclude the risk could be reduced or to assess the level of residual risk following implementation of protective measures. Moreover, even if the Staff believes the risk of terrorism-related impacts is "acceptable," it still must disclose in Appendix B what that risk is. Finally, NEPA requires the Staff to discuss and disclose terrorism-related "impacts which have catastrophic consequences, even if their probability of occurrence is low." 40 C.F.R. § 1502.22(b)(3).

Nor does it give the public any information regarding where these security assessments can be found, so the public can review them and assess the manner in which the Staff used them to analyze threats to Pa'ina's proposed irradiator. NEPA expressly prohibits incorporation by reference of materials like the generic assessments since they are not "reasonably available for inspection by potentially interested persons within the time allowed for comment." 40 C.F.R. § 1502.21; see also NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," § 1.6.4 (2003) (same).

- Information about assumptions on which Staff relied. Appendix B states that its finding of no significant impact is based on "assumptions ... regarding irradiator design and the source term," yet it fails to disclose what those assumptions are and how the Staff determined that the assumptions are applicable to the Pa'ina irradiator. Appendix B at B-5. Appendix B also fails to discuss how these assumptions support the ultimate conclusion that the consequences of a terrorist attack would not be significant.
- Scientific support for the Staff's assumption that the proposed irradiator and source materials are so "robust" that a terrorist attack would result in "generally small radiological consequences." Appendix B at B-6. As discussed above, NEPA requires the Staff to "insure the professional integrity, including scientific integrity, of [its] discussions and analyses" and to disclose the methodologies, standards, and calculations it used to assess the vulnerability of the proposed irradiator to terrorist attack. 40 C.F.R. § 1502.24.
- Data supporting the Staff's assertion that "immediate health effects from exposure to ... low radiation levels ... are expected to be minimal." Appendix B at B-6. Although Appendix B cites to another document, that document merely repeats the same statement, without providing the requisite scientific support.
- Methodology and data used to determine that the risk of terrorist attack involving Pa'ina's irradiator would be at an "acceptable level." Appendix B at B-7, including the Staff's definition of what constitutes an "acceptable level."³

"Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA." 40 C.F.R. § 1500.1(b). Appendix B fails to satisfy NEPA's basic requirements since it does not disclose the underlying sources, assumptions, and data on which it bases its conclusion that the environmental and health effects of a terrorist attack on the Pa'ina irradiator would be small.

³ Under NEPA, even if the Staff had made a defensible, scientific determination that the risk is within an "acceptable level," it still would have to take a hard look at all reasonably foreseeable impacts, including impacts with a low probability of occurrence. 40 C.F.R. § 1502.22(b)(3).

Failure to address significance of identified effects

The major purpose of the Draft EA is to help the NRC determine whether approving Pa'ina's proposed irradiator "may have a significant effect upon the environment," triggering the NRC's obligation to prepare an environmental impact statement ("EIS"). National Parks & Conservation Ass'n v. Babbitt, 241 F.3d 720, 730 (9th Cir. 2001) (quoting Foundation for N. Am. Wild Sheep v. United States Dep't of Agric., 681 F.2d 1172, 1178 (9th Cir. 1982)) (emphasis in National Parks & Conservation Ass'n). The significance analysis must consider both context, including the extent of the geographic area and the interests that may be affected, and intensity (severity) of the impact, looking specifically at factors like the unique characteristics of the area, uncertainty of the consequences, and controversy. 40 C.F.R. § 1508.27.

Appendix B identifies "[t]he most likely outcome of an act of sabotage" as "some of the sources would be damaged and some 'slugs' of cobalt metal could be released to the pool water." Appendix B at B-6. Having identified this likely effect, Appendix B improperly provides only a cursory analysis of its significance, stating in a conclusory fashion that "there is a low risk of radioactive material escaping the pool." Id. Even if the Staff's quantification of the level of risk were supported by rigorous analysis (and it is not), nowhere does Appendix B discuss the significance of the environmental impacts in the allegedly "low risk" scenario in which radioactive material escapes the pool. 40 C.F.R. § 1502.22(b)(3) (requiring disclosure of "impacts which have catastrophic consequences, even if their probability of occurrence is low"). As Dr. Resnikoff explains, if a terrorist group punctures the pool and damages the "slugs," radioactive materials could escape and contaminate the area surrounding the pool, including Honolulu International Airport and/or Ke'ehi Lagoon, which is connected to the Pacific Ocean. See Resnikoff Report at 5. The NEPA regulations set forth specific factors the NRC must consider in analyzing the significance of potential impacts (40 C.F.R. § 1508.27); it is not permissible for the Staff to simply mention a potential impact without weighing the significance of that impact.

The analysis of the impacts of a theft or diversion of radioactive material for use in a "dirty bomb" is similarly flawed. Appendix B notes that dirty bombs are "weapons of mass disruption" and that incidents involving a dirty bomb using Cobalt-60 from Pa'ina's irradiator "could create fear and panic, contaminate property, and require potentially costly cleanup," and could "result in radioactive contamination of several city blocks to an entire city," as well as cause immediate deaths or serious injuries. Appendix B at B-6. All of these potential effects appear, on their face, to be significant. The Staff provides no basis for its contrary finding that potential impacts would be insignificant.⁴

⁴ The Staff apparently considers the deaths and injuries irrelevant because they "would likely result from the explosion itself, rather than from radiation exposure." Id. There is no justification for ignoring the loss of human life, since, in the absence of radioactive material at Pa'ina's facility, there would be no dirty bomb and, thus, no explosion and associated deaths and injuries.

According to Appendix B, the extent of contamination from a dirty bomb “depends upon a number of factors including the size of the explosive, the amount and type of radioactive material used, and weather conditions.” *Id.* To quantify the significance of the effects of a dirty bomb, the Staff could, and should, have considered these factors as they apply to Pa'ina's proposed irradiator. The Staff knows, for example, that Pa'ina has requested a license for one-million curies of Cobalt-60. Using this specific information, it could assess the size of the area that would likely be contaminated, as well as the extent of the contamination, allowing the Staff to evaluate the likely effects of a dirty bomb blast on Honolulu's populace and economy and to estimate the potential length and cost of cleanup. A Federation of American Scientists report determined, for example, that, if just 17,000 curies of Cobalt-60 were dispersed by an explosion at the lower tip of Manhattan, an area of approximately one-thousand square kilometers could be contaminated, and tens of thousands of New York City residents could be exposed to high levels of radiation. *See Resnikoff Report at 5.*⁵ By failing to conduct a similar analysis to determine the significance of a terrorist attack involving Pa'ina's specific proposed irradiator, the Staff has failed to take the hard look required by NEPA.

Failure to consider all reasonably foreseeable impacts

To comply with NEPA, Appendix B must consider all impacts associated with Pa'ina's proposed irradiator, whether they are immediate, direct effects or indirect, but reasonably foreseeable effects. 40 C.F.R. § 1508.8. The Staff inappropriately focuses on only the immediate effects of a potential terrorist attack on the irradiator, failing to provide any analysis of the long-term human health and environmental effects of up to one million curies of radioactive Cobalt-60, dispersed by a bomb, persisting in the environment. NEPA regulations specifically state that “both short- and long-term effects are relevant” in determining significance. 40 C.F.R. § 1508.27(a).

Further, Appendix B provides no analysis of the potential for a terrorist attack on the nuclear material while in transit. According to the Draft EA, radioactive sources would be shipped to the Pa'ina facility approximately once per year. As discussed in the comments Earthjustice submitted regarding the Draft EA, sources in transit from Canada or Russia to the Pa'ina irradiator would not be well-protected from a terrorist attack, and an attack on a shipment in transit could cause major environmental pollution and cancer fatalities, as well as significant economic impacts. Because these shipments will occur only if the NRC licenses Pa'ina's irradiator, the shipments are a connected action, and the Staff must examine the potential effects of a terrorist attack on a shipment of Cobalt-60. *See* 40 C.F.R. § 1508.25(a)(1) (discussing “connected actions”). Appendix B unlawfully fails to do so.

⁵ Earthjustice enclosed a copy of the Federation of American Scientists report in its February 8, 2007 comments on the Draft EA.

Improper reliance on inadequate mitigation measures

To justify its finding of no significant impact, the Staff relies heavily on “enhanced security compensatory measures” that it claims would be “adequate and effective in countering and mitigating the effect of terrorist attacks[.]” Appendix B at B-7. These security measures include “enhanced access controls; background screening of personnel; intrusion detection, assessment and alarm response; and coordination with local law enforcement.” *Id.* Under NEPA, “[m]ere listing of mitigation measures, without supporting analytical data is insufficient to support a finding of no significant impact.” National Parks & Conservation Ass’n, 241 F.3d at 733. Instead, the Staff must show “the mitigation measures will render [negative] impacts so minor as to not warrant an EIS.” *Id.*

The Staff states that the security measures “are intended to prevent the theft of radioactive material[.]” “assure prompt response by law enforcement,” and “mitigate severe consequences of potential terrorist actions.” Appendix B at B-7. The Staff fails, however, to provide any analytical data to support its conclusions.⁶ Moreover, nothing in Appendix B suggests these mitigation measures could eliminate the potential for a terrorist attack with catastrophic consequences. Rather, the most the Staff claims is that the mitigations would “reduce[] the risk” of such an attack. *Id.* Since, even with full implementation of all mitigation measures, the potential for significant impacts from terrorism would remain, the Staff cannot lawfully make a finding of no significant impact.

Failure to consider reasonable alternatives

In its February 8, 2007 comments on the Draft EA, Earthjustice explained how the Staff’s failure to evaluate alternate technologies and alternate locations for Pa’ina’s proposed irradiator violated NEPA’s mandate to consider “choices or alternatives that might be pursued with less environmental harm.” Lands Council v. Powell, 395 F.3d 1019, 1027 (9th Cir. 2005). That the Staff’s refusal to consider reasonable alternatives undermines NEPA’s goal of informed decision-making is particularly glaring in the context of evaluating terrorist threats. Alternate technologies that do not use nuclear material would completely eliminate the potential for dirty bombs, while alternate locations far from tempting targets like the international airport and Pearl Harbor and far from highly populated urban Honolulu would decrease both the likelihood of terrorist attack and the consequences should an attack occur. Because the Staff failed to consider reasonable alternatives, neither the NRC nor the public can evaluate “possible approaches to a particular project ... which would alter the environmental impact and the cost-benefit balance,” subverting Congress’s intent in enacting NEPA. Bob Marshall Alliance v. Hodel, 852 F.2d 1223, 1228 (9th Cir. 1988) (quoting Calvert Cliffs’ Coordinating Comm., Inc. v. United States Atomic Energy Comm’n, 449 F.2d 1109, 1114 (D.C. Cir. 1971)).

⁶ While Appendix B cites “The Radiation Source Protection and Security Task Force Report” (Aug. 15, 2006), that report fails to provide the missing analytical support for the Staff’s conclusory statements.

Concerned Citizens Comments on Appendix B: Consideration of
Terrorist Attacks on the Proposed Pa'ina Irradiator

July 9, 2007

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Conclusion

While Concerned Citizens appreciates that the NRC Staff has finally conceded the need to consider potential impacts of terrorism involving Pa'ina's proposed irradiator, Appendix B falls far short of satisfying NEPA's requirements to prepare a sound, science-based analysis of both the risk and all potential consequences of a terrorist attack. Consequently, the Staff may not lawfully rely on Appendix B to support a finding of no significant impact.

We appreciate the opportunity to provide these comments, which hopefully will prompt the Staff to satisfy its obligations under NEPA by preparing a revised terrorism analysis. Please feel free to contact me should you wish to discuss our concerns.

Sincerely,



David Lane Henkin
Staff Attorney

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Enclosure

Analysis of the Vulnerability and Potential Consequences of a Terrorist Attack on the Proposed Pa'ina Hawaii Irradiator

NRC Docket No. 030-36974

**By
M. Resnikoff, Ph.D.**

**For
Earthjustice**

July 6, 2007

Radioactive Waste Management Associates (RWMA) prepared this report to analyze the adequacy of the Nuclear Regulatory Commission (NRC) Staff's Appendix B, Consideration of Terrorist Attacks on the Proposed Pa'ina Irradiator (Appendix B). Pa'ina Hawaii seeks a license from the NRC for up to one-million curies of Cobalt-60 (Co-60) for use in its underwater pool irradiator, which it proposes to build near the Honolulu International Airport. Appendix B supplements the Staff's draft Environmental Assessment for the proposed Pa'ina irradiator.

In preparing this report, RWMA reviewed the information in the June 7, 2007 NRC Staff Hearing File Index Update and the references listed in Appendix B. The list of reviewed references is attached hereto as Appendix 1. We note some vital information is unavailable, including "Results of Implementation of the Decisionmaking Framework for Materials and Research and Test Reactor Security Assessments," U.S. Nuclear Regulatory Commission, SECY-06-0045, March 1, 2006, referenced in Appendix B. In its June 7, 2007 Hearing File Index Update, the Staff asserts that this document may be confidential. Appendix B fails to disclose, however, whether the Staff is treating this document as confidential, and if so, on what grounds.

As discussed in detail below, RWMA concludes that the information provided in Appendix B and the referenced documents fail to adequately discuss 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. As shown below, it is possible to quantify the vulnerability of the Pa'ina Hawaii irradiator. A thorough analysis of the threats, vulnerability, and potential consequences of an attack would allow the NRC to make an informed decision about the risk and potential significance of a terrorist attack on the Pa'ina Hawaii irradiator.

THREAT

Because information regarding the Design Basis Threat (DBT) is not known, we proceed under the assumption that "a general credible threat" of a terrorist attack exists, as does the NRC Staff. Appendix B at B-4. A DBT would need to describe the type of arms and explosives available to saboteurs, the number of persons in an armed group, and their

training. We would also need to know the intent of saboteurs. For purposes of our analysis, we will assume an armed group would have the equipment detailed below and the intent to use it. We will also assume there is no resistance to an armed assault, and that tear gas or nerve gas would be employed.

International Atomic Energy Agency (IAEA) Safety Guide No. RS-G-1.9, "Categorization of Radioactive Sources," August 2005, places irradiators that use between 5,000 and 15 million curies of Co-60 in Category 1. The Pa'ina irradiator, which would be licensed to possess up to one-million curies of Co-60, falls within Category 1. 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." IAEA Safety Guide No. RS-G-1.9 at 5.

VULNERABILITY

In determining the vulnerability of the Pa'ina Hawaii irradiator, we considered three plausible scenarios involving a determined sabotage group.¹ In scenario one, we assumed that the saboteurs dropped an M3A1 shaped charge to the bottom of the irradiator pool. Under scenario two, we assumed that the saboteurs would have the use of a TOW2 or MILAN anti-tank missile. Scenario three assumed that saboteurs would crash a Boeing 757 into the building at greater than 100 mph. This is a valid assumption, because under normal conditions B757's take-off and land at about 180 mph. The plausibility is even greater given the irradiator's location next to the runways of the Honolulu International Airport.

We further assumed that the irradiator pool containing the Co-60 sources is composed of two steel shells 0.25 inches thick, with six inches of concrete sandwiched between; that there will be no resistance to an armed assault; that the saboteurs may use tear gas or nerve gas to disable the irradiator staff; and that the saboteurs have the ability to punch a hole through the exterior wall of the irradiator building (e.g., by using an armored car).

As detailed below, our calculations show that 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, our calculations again showed that the force from the TOW2 or MILAN anti-tank missile could punch a hole through the side of the pool. In scenario three, we based our calculations on the shaft of a Rolls Royce jet engine puncturing the pool wall and found that the engine could puncture the pool. After describing the methodology applied to make these calculations, we discuss the potential consequences of these three scenarios.

¹ This report focuses on the vulnerability of the proposed irradiator to a sudden, violent terrorist attack. Other plausible modes of attack exist that the NRC should also consider, including 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.

METHODOLOGY

To calculate the vulnerability of the Pa'ina irradiator, we first considered the perforation thickness of the irradiator pool. The perforation thickness is the thickness that is just great enough to allow a missile to pass through without any exit velocity. From DOE-STD-3014-2006, the perforation thickness for concrete is:

$$t_p = \left(\frac{U}{V} \right)^{0.25} \left(\frac{MV^2}{Df_c} \right)^{0.5}$$

Where:

- U = reference velocity = 200 ft/sec;
- V = missile impact velocity (ft/sec);
- M = mass of the missile = W/g,
where: W = missile weight (lb),
g = 32.2 ft/sec²;
- D = effective missile diameter (ft);
- f_c = ultimate compressive strength of concrete (lb/ft²);
- t_p = scabbing thickness (ft)

For steel, the perforation thickness is :

$$T^{1.5} = \frac{0.5MV^2}{17,400K_s D^{1.5}} \quad (8-3)$$

where:

- T = predicted thickness to just perforate a steel plate (in.);
- M = W/g missile mass (lb-sec²/ft);
- V = missile impact velocity (ft/sec);
- K_s = constant depending on the grade of steel (usually = 1);
- D = missile diameter (in.).

To calculate the perforation thickness of the irradiator pool, we combine the kinetic energy (KE = ½ MV²) required to penetrate concrete (6 inches) with the kinetic energy required to penetrate steel to obtain the velocity to penetrate the irradiator wall. Table 1 below lists the results. The calculations show that both the M3A1 charge and the Milan anti-tank missile easily penetrate the irradiator pool wall. For example, the Milan anti-tank missile can penetrate 4 feet of concrete and 1 meter of steel.

		Missiles and Planes						
Symbol	Parameter	M3A1 shaped charge	Milan anti- tank missile	TOW 2A Anti- tank missile	TOW 2 Anti-tank missile	RPG-7	M72 66mm	B757 Rolls Royce engine
M	missile mass (slugs)	1.24	6.88	1.55	61.73	22.37	7.61	225.00
V	missile impact velocity (ft/sec)	7131.50	688.98	1079.00	656.17	984.25	656.17	600.00
Ks	constant depending on steel grade	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D	missile diameter (inches)	9.00	5.24	5.87	5.00	3.35	3.46	74.40
Pc	ultimate compressive strength	720000	720000	720000	720000	720000	720000	720000
T	penetration depth (inches)	16.54	3.94	2.37	16.71	21.79	5.97	2.36
	penetration depth (mm)	420.00	100.16		424.47	553.51	151.69	59.96
	reported penetration depth (mm)	--	>1000		>700	>330	350.00	--
Tp (ft)	perforation thickness into concrete	4.43	2.37	1.49	6.99	6.98	2.95	3.24

The diameter of the shaft of the B757 Rolls Royce engine is 25 inches. The minimum velocity for the engine shaft to perforate the irradiator pool is 103 mph. Since Boeing-757s commonly land and take off at 180 mph, saboteurs who take command of a B757 and hit the irradiator pool could puncture the pool liner. This is shown in Table 2 below.

Table 2. Minimum Velocity to Puncture Irradiator Liner

steel	concrete	total KE	velocity (fps)	velocity (mph)	
KE=(0.5MV ²)					
768978.62	1785826.18	2554804.81	150.70	102.75	B757 RR engine
166099.38	2587628.86	2753728.25	2105.59	1435.63	M3A1 shaped charge
73710.80	710407.65	784118.45	477.49	325.56	Milan anti-tank missile

CONSEQUENCES

The above calculations show, contrary to the NRC staff's assertion in Appendix B, that the Pa'ina irradiator is vulnerable to attack. In any of the three scenarios discussed above, following puncture of the pool liner, a party of saboteurs could ignite a combustible material 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. For example, following the detonation of a platter charge or a hit with a Milan anti-tank missile, the saboteurs could pour jet fuel or gasoline into the empty pool and over the sources, then set the fuel on fire, dispersing radioactive material. In the case of diverting a commercial airplane as a terrorist device, jet fuel would already be present in large quantities.

A recent gasoline fire in Oakland, CA burned at an estimated 3,000 °F, and softened bridge support on an Interstate ramp, causing it to fall. NRC contractor reports estimate jet fuel fires at 1800 °F. It is incumbent on NRC staff to estimate the temperature of a fire within the proposed irradiator facility, taking into account this recent fire.

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 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 300 hundred city blocks.

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 affect Hawaii's economy, which depends on air shipments for food, goods, and mail service, and could also disrupt Hawaii'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 Hawaii and cause a decline in tourism.

Appendix 1

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