UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE, L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Independent Spent Fuel Storage Installation)	)	

NRC STAFF'S REPLY FINDINGS OF FACT AND CONCLUSIONS OF LAW CONCERNING UNIFIED CONTENTION UTAH L/QQ (GEOTECHNICAL ISSUES)

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I. INTRODUCTION [1]

1.21. In accordance with the Licensing Board's scheduling Order of August 21, 2002, proposed findings of fact and conclusions of law concerning Unified Contention Utah L/QQ (Geotechnical Issues) were timely filed by Private Fuel Storage, L.L.C. ("PFS" or "Applicant"), the State of Utah ("State"), and the NRC Staff ("Staff") on September 5, 2002.[2] Pursuant to the Licensing Board's Order of August 21, the Staff herewith files its reply to the Applicant's and State's proposed findings of fact and conclusions of law concerning Unified Contention Utah L/QQ.[3]

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[1] The paragraph numbering system in these Reply Findings generally follows the numbering utilized in the "NRC Staff's Findings of Fact and Conclusions of Law Concerning Unified Contention Utah L/QQ (Geotechnical Issues)" ("Staff's Findings" or "Staff PF"), dated September 5, 2002. Thus, Staff Reply Finding ¶ 1.21 should be read to follow ¶ 1.20 in the Staff's Findings of September 5, 2002.

[2] *See* (1) "Applicant's Proposed Findings of Fact and Conclusions of Law on Unified Consolidated Contention Utah L/QQ (Seismic)" ("Applicant's Findings" or "App. PF"), (2) "State of Utah's Proposed Findings of Fact and Conclusions of Law on Unified Contention Utah L/QQ" ("State's Findings" or "State PF"), and (3) Staff's Findings, dated September 5, 2002.

[3] The Staff has reviewed the Applicant's Findings and has determined that a detailed reply thereto is not required. In this regard, the Staff has concluded that the Applicant's Findings are not inconsistent with the Staff's Findings, and any important substantive differences between the Staff's and Applicant's respective views of the evidence are reflected in their proposed findings of fact and conclusions of law filed on September 5, 2002.

1.22. In its proposed Findings, the State asserts that the Commission may not take economic costs into account in determining whether to issue a license for the PFS ISFSI, in support of which it cites *Union of Concerned Scientists v. NRC*, 824 F.2d 108 (D.C. Cir. 1987). *See* State's Findings at 5-7. This argument is irrelevant here. The Licensing Board has not been asked to render a decision in this matter based upon the economic costs of compliance with NRC regulations, nor did the parties address that issue in their testimony.[4] Further, the State has never amended its contention to include any assertions concerning economic costs, and it is too late to do so now.[5] Accordingly, the issue of economic costs is not properly before the Licensing Board.

1.23. The State argues that issuance of an exemption from the "design basis" regulations would "dilute the margin of safety the Commission has built into 10 CFR § 72.106(b)." State's Findings at 11. This is incorrect. The Applicant's proposed exemption would allow it to utilize probabilistic methodology and a 2,000-year return period ground motion in establishing the design basis for its ISFSI. The same dose standard, however, would apply, to the consequences of any accident or design basis event, including earthquakes. *See* Staff PF ¶¶ 6.127-6.128, 6.227.[6]

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[4] The sole evidence cited in the State's Findings that in any way touches upon economic costs, involved a single statement by Staff witness Dr. Martin McCann in response to a question from Judge Kline, in which he explained that a 2,000-year return period provides adequate protection of public safety -- and stated, <u>in addition</u>, that "4,000 gives you more safety, obviously. Is it more for, you know, too much money, thinking of the public's general interest? That's I think where you would argue that yeah, maybe 4,000 is not the way to go." Tr. 8278; *see* State PF ¶ 587. Notably, economic costs were not addressed in any of the parties' prefiled testimony.

[5] *See, e.g., Private Fuel Storage L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-20, 56 NRC ___ (Oct. 1, 2002), slip op. at 2 (claims that were not included in an intervenor's original contention were barred from litigation, in that "[i]t is neither fair nor consistent with our usual practice to allow a last-second infusion of new elements into a previously admitted contention."

[6] The same result would apply where nuclear power plant applicants seek to utilize probabilistic methodology in establishing their seismic design bases under 10 C.F.R. § 100.23 -- *i.e.*, the resulting design basis may be less stringent than if it had been calculated with a deterministic approach under Appendix A, but the accident dose standard would be the same. *See, e.g.*, 10 C.F.R. §§ 52.48, 52.83 (applying the standards in 10 C.F.R. Parts 20 and 50).

1.24. The State asserts that the Board must consider "the public interest" under 10 C.F.R. § 72.7, and it argues that this term embraces something that is "distinct and separate" from safety considerations. *See* State's Findings at 11. According to the State, the Board must determine "in what respects is an unconventional and untested nuclear facility in Utah, with a relaxed seismic design earthquake standard, in the public interest" -- particularly in light of "the fallout legacy" in Utah resulting from earlier Nevada test site nuclear weapons testing. *Id.* at 11-12.[7]

1.25. Significantly, however, the State has not heretofore raised the issue of whether the exemption is in the public interest as an issue that is "distinct and separate" from the safety issues raised in Unified Contention Utah L/QQ -- and its contention is devoid of any reference to the public interest as an issue that is distinct and separate from safety. Indeed, when the Commission accepted this part of the contention for litigation (then formulated as Contention Utah L, Part B), it observed that the issues raised by the State did not involve the exemption itself, but only the safety of the proposed seismic design under the exemption:

> The Board's certified question and the parties' briefs consider whether PFS's request for an exemption -- *i.e.*, a determination that PFS need not meet the "design earthquake" standard set out in 10 C.F.R. §§ 72.102(f)(1) -- is an appropriate subject for an NRC hearing. *See* LBP-01-03, 53 NRC at 100. To speak in terms of a hearing on PFS's exemption is a convenient shorthand, which we ourselves use in today's order. It is important to recognize at the outset, though, that the certified question does not focus directly on the exemption itself, but, as the Board said, on "exemption-related matters." *Id.* At bottom, what Utah proposes to litigate is whether PFS's ISFSI design, which is dependent on an exemption from otherwise controlling seismic regulations, is adequate to withstand plausible earthquake risks. Viewed this way, Utah's proposed revised Contention L (geotechnical) plainly puts into play safety issues that are material to licensing and suitable for consideration at an NRC hearing.

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[7] While the State proposes its own "public interest" question, a more pertinent question may be whether, considering the potential benefits of the facility, "it is contrary to the public interest . . . to impose requirements which are totally unnecessary or which are out of line with the risks involved." *See Quivera Mining Co.* (Ambrosia Lake Facility Grants, New Mexico), CLI-98-11, 48 NRC 1, 16 n.6 (1998), *citing* 128 Cong. Rec. S15313 (Dec. 16, 1982) (statement of Sen. Schmitt).

Private Fuel Storage L.L.C. (Independent Spent Fuel Storage Installation), CLI-01-12, 53 NRC 459, 465-66 (2001) (emphasis added).[8]

1.26. In sum, contrary to the State's current argument, the State's contention, as admitted, does not require the Licensing Board to consider issues that are separate and distinct from the safety of the proposed seismic design under the PFS exemption request, in that any such additional issues were not raised in this contention. The State's effort to raise additional issues at this time should be rejected, as contrary to the Commission's established practice of disallowing litigation of matters which constitute "a last-second infusion of new elements into a previously admitted contention." *Private Fuel Storage L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-20, 56 NRC ___ (Oct. 1, 2002), slip op. at 2.[9]

1.27. In its proposed Findings, the State seeks to limit the weight to be accorded to the testimony of various Applicant and Staff witnesses. Among others, the State specifically challenges the testimony of PFS witnesses Drs. Krishna Singh and Alan Soler -- who, as principals

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[8] The Commission further explained its decision to admit exemption-related safety issues for litigation, as follows:

> PFS's 'exemption' cannot remove a matter germane to a licensing proceeding from consideration in a hearing, assuming an interested party raises an admissible contention thereon. To hold otherwise would exclude critical safety questions from licensing hearings merely on the basis of an 'exemption' label.

CLI-01-12, 53 NRC at 467 (emphasis added; footnote omitted).

[9] In deciding to allow litigation of the adequacy of the bases stated in the Staff's Safety Evaluation Report ("SER") for approving the proposed exemption, the Commission observed that "PFS has the burden to show that the exemption is 'authorized by law, will not endanger life or property or the common defense or security, and [is] otherwise in the public interest. 10 C.F.R. § 72.7." CLI-01-12, 53 NRC at 473. In doing so, however, the Commission did not identify any issue in the State's contention that requires litigation other than the adequacy of the proposed seismic design and the Staff's stated bases for approving the exemption request. Moreover, as the State, itself, observes, the Staff's bases for approving the exemption request did not address the "public interest" as an issue separate and distinct from the Staff's consideration of the safety of the seismic design under the requested exemption. *See* State PF ¶ 586; Tr. 8249-53.

of Holtec International, allegedly stand to reap "enormous economic benefits" from the licensing of the PFS Facility. *See, e.g.*, State's Findings at 18-19, 171, and 257-260. While the record does not show the precise amount of financial benefit that may accrue to those individuals, it is not unreasonable to expect that those benefits could indeed be large (although that outcome is not assured). *See* Staff PF ¶ 5.221, *infra*. However, while the State argues that these potential financial benefits result in "extreme bias and self-interest," it fails to point to any specific testimony that it believes has been shown to lack credibility due to this alleged bias -- although one would expect to find such examples where inadequate analytical work or biased testimony is subjected to extensive cross-examination and Board questioning.[10] In other words, witness credibility may be measured by how well they are able to defend their analyses and testimony under cross-examination and Board questioning. On the basis of the evidence before us and our observation of the witnesses, we find no reason not to accord full evidentiary weight to their testimony.[11]

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[10] While the State cites the potential for economic bias, it omits reference to other factors which reasonably may be expected to constrain such potential bias. For example, applicants or licensees (such as PFS and Holtec) that make material false statements in an NRC proceeding run the risk of criminal penalties and agency enforcement actions. *See* Tr. 10958; *see generally*, 10 C.F.R. §§ 72.12, 72.60; Atomic Energy Act of 1954, as amended, §§ 186, 223 and 234, 42 U.S.C. §§ 2236, 2273, 2282. Also, the Staff's independent evaluation of the testimony and underlying safety analyses may be viewed to provide "an additional safeguard against bias in NRC licensing proceedings." *See Louisiana Power & Light Co.* (Waterford Steam Electric Station, Unit 3), ALAB-732, 17 NRC 1076, 1091 n.18 (1983).

[11] By the same token, one might argue that the State witnesses' testimony may be biased because the State opposes the licensing of the PFS Facility and its witnesses are either directly employed by the State (Drs. Arabasz, Bartlett and Solomon), or are employed as State consultants (Drs. Khan, Mitchell, Ostadan and Resnikoff). However, as in the case of the PFS witnesses, we have considered the State's testimony on its merits and on the basis of its witnesses' candor and responses to cross-examination and Board questioning, in assessing their credibility.

II. FINDINGS OF FACT

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C. Unified Contention Utah L/QQ, Part C.

1. Geotechnical Site Characterization.

4.155. The State asserts that Staff witness Dr. Ofoegbu has no "direct experience" with Bonneville clays, and is not a registered engineer in the United States (State PF ¶ 3). The State, however, ignores two important facts. First, while Dr. Ofoegbu has not worked with Bonneville clay, *per se*, Bonneville clay is a mixture of "silty clays and clayey silts" (Staff Exh. C at 2-56) -- which is a common classification for engineering soils, and Dr. Ofoegbu has direct experience working with that kind of soil. Tr. 11006-07, 11027-28. Second, although not registered in the United States, Dr. Ofoegbu is a registered engineer in Canada -- where he received his M.A.Sc. and Ph.D. degrees in Geological Engineering from the University of Toronto. *See* Ofoegbu Qualifications, Post Tr. 11001, at 1; Tr. 6550; Staff PF ¶ 4.12. Thus, the State's challenge to his qualifications does not present a valid concern. Further, we find Dr. Ofoegbu to be well qualified to address the matters which are the subject of his testimony, and do not accept the State's suggestion that Dr. Bartlett's testimony should be accorded greater weight than the testimony of Dr. Ofoegbu. State PF ¶ 5.

4.156. The State asserts that "for extreme environmental events, such as earthquakes, a factor of safety of at least 1.1 is considered inviolable." State PF ¶ 10, *citing* Tr. 11845-48 (Bartlett). This reflects an incorrect understanding of NRC regulatory requirements. In fact, the 1.1 factor of safety against overturning and sliding is established in an NRC regulatory guidance document, NUREG-0800, § 3.85 (Staff Exh. EE), at 3.8.5-7; as such, it is not a binding regulatory requirement.

See Staff PF ¶¶ 4.50, 5.74, 5.184, and n.98.[12] As Dr. Ofoegbu explained, the factor of safety of 1.1 constitutes guidance as to how an applicant may demonstrate compliance with the regulatory requirements of 10 C.F.R. § 72.122(b)(2); this guidance does not preclude an applicant from demonstrating the safety of its facility on some basis that is entirely different than demonstrating the existence of a 1.1 factor of safety. Tr. 6594-97, 6740-41.

4.157. In its proposed Findings, the State asserts that (a) "PFS relies on the cohesive strength of the upper Bonneville clays to provide seismic stability" (State PF ¶ 12); (b) "the soil layer upon which PFS is relying to resist all the seismic loads is the upper Bonneville clays" (State PF ¶ 13); and (c) "for seismic analysis the upper Lake Bonneville clays are the critical soil layer at the PFS site" (State PF ¶ 17). These statements are incorrect.[13] As used in the State's Findings, the term "upper Bonneville clays" refers only to Layer 1B (approximately the upper 10 feet) of the underlying soils. In its analyses, the Applicant relies upon the shear strength of the Upper Bonneville clays (layer 1B) for the sliding stability of the storage pads and CTB foundation. For bearing capacity, the Applicant utilized the undrained shear strength of the layer 1B soils (the weakest layer) to establish the bearing capacity of the pads and CTB foundation; however, this was a conservatism, in that it could have used the average shear strength for the top 30-ft soil layer *(i.e.,* layer 1 in its entirety) in its bearing capacity analysis for the pads, or the average shear strength for the top 240-ft soil layer (*i.e.*, layers 1 and 2) in its bearing capacity analysis for the CTB

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[12] *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255, 264 (2001) ("NUREGs, such as the Standard Review Plan, like all guidance documents, are not legally binding regulations" (citations omitted)).

[13] Moreover, the State's assertion that "all parties agree that for seismic analysis the upper Lake Bonneville clays are the critical soil layer at the PFS site" (State PF ¶ 17, emphasis added) is incorrect; nor does the State point to any testimony by the Staff that supports this statement. Indeed, we note that the State's Findings contain scant reference to the testimony of Staff witnesses Dr. Goodluck Ofoegbu and Daniel Pomerening.

foundation. The Applicant's use of the values for the layer 1B soils thus provides a conservative lower-bound estimate of the permissible value. Ofoegbu Post Tr. 11001, at 7.

4.158. The State asserts that "Mr. Trudeau claims that the upper Bonneville clays are uniform but he did admit there is some variability in those soils." State PF ¶ 19, citing Tr. 11750. In fact, Mr. Trudeau's testimony concerned the "horizontal consistency" of the soils at the site, and the Geomatrix site investigations which confirmed that "the soils in approximately the top 30 feet of the subsoil are fairly uniform and consistent in the horizontal direction across the site." Trudeau/Wissa Post Tr. 10834, at 7. It was in this respect that Mr. Trudeau stated that "there's little variability" in strength, as evidenced by the CPT tip resistance data. Tr. 11750.

4.159. The State asserts that "PFS has not determined what percentage of the upper Bonneville clays are a plastic soil using the soil classifications (*i.e.*, a CH or MH material)." State PF ¶ 19, citing Tr. 11751 (Trudeau). While this statement is correct, it overlooks the fact that PFS did identify the plasticity of the soils at the site, based on actual data. *See* PFS Exhs. 233, 233A. Further, the index classification of the Skull Valley soils (including the Upper Bonneville clay) is given in borehole logs in Appendix 2A of the PFS SAR. Trudeau/Wissa Post Tr. 10834, at 6; Staff Exh. C (Consolidated SER), at 2-55 - 2-56; PFS Exhs. 233, 233A.

4.160. In light of this evidence, there is no basis for the State's further assertion that "because PFS has failed to classify the plasticity of the upper Bonneville clays, it cannot claim that there is uniformity across the site" (State PF 20). To the contrary, the CPT and borehole data support the Applicant's conclusion that soil properties are uniform in the lateral direction at the site, as Dr. Ofoegbu agreed. *See* Tr. 11816-17.

4.161. The State asserts that PFS used an approximate spacing of boreholes and cone penetrometer tests of 221 feet in the pad area (State PF ¶ 26). In contrast, the State points to the recommendation of a 100-ft spacing of boreholes for NPP safety-related structures, as set forth

in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Rev. 1, March 1979) (State Exh. 97). The State urges us to conclude that because of this spacing, the Applicant's site investigation should be deemed to be insufficient (State PF ¶¶ 25, 27). However, the State fails to afford sufficient attention to the cautionary instruction placed in Reg. Guide 1.132, which states that it provides "general guidance" only, and that alternative site investigation programs may be acceptable, depending on the nature of the site:

> Because the details of the actual site investigations program will be highly site dependent, the procedures described herein should be used only as guidance and should be tempered with professional judgment. Alternative and special site investigative procedures that have been derived in a professional manner will be considered equally applicable for conducting foundation investigations.

State Exh. 97, at 1.[14] To be sure, Reg.Guide 1.132 specifically applies to nuclear power plants, and is not directly applicable to ISFSIs. *See* Trudeau/Wissa Post Tr. 10834, at 13-14. However, this caveat aside, the cited guidance in Reg. Guide 1.132 would allow for alternative spacing based upon site-specific conditions; and in view of the general horizontal uniformity in soils that was found to exist at the PFS site, we cannot find that its borehole/CPT spacing is inadequate, *per se* --

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[14] Reg. Guide 1.132 includes the following additional guidance concerning subsurface investigations (Id. at 1.132-3):

> The appropriate depth, layout, spacing, and sampling requirements for subsurface investigations are dictated by the foundation requirements and by the complexity of the anticipated subsurface conditions. . . .
>
> Subsurface conditions may be considered favorable or uniform if the geologic and stratigraphic features to be defined can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may occur. Uniform conditions permit the maximum spacing of borings for adequate definition of the subsurface conditions at the site.

particularly in view of the Applicant's conservative determination to utilize the weakest sublayer (*i.e.*, layer 1B, or the "upper Bonneville clays") to represent the site foundation in its analyses.

4.162. The State suggests that PFS is remiss, in that it did not "conduct any statistical analysis of the CPT data to determine the variability of the upper Bonneville clays," and "did not analyze the range or standard deviation of the tip resistance across the site." State PF ¶ 32. However, we are aware of no reason why statistical methodology should be required, particularly where the data may readily be portrayed in a graphic manner, such that its import is readily observable. *See, e.g.*, PFS Exh. 233, 233A; Staff Exh. C, at 2-56.

4.163. The State claims that "the visual representation of the CPT data on PFS Exh. 233a is a depiction of the relative stiffness of the tip resistance of the cone penetrometer, not of the shear strength of that layer." State PF ¶ 33, *citing* Tr. 11948-49, 11868-73 (Bartlett). This claim misconstrues Dr. Bartlett's testimony. Dr. Bartlett stated that *in situ* CPT testing measures stiffness, which is then correlated to shear strength; he did not state that shear strength cannot be derived from CPT data. *See* Tr. 11949, 11868. To the contrary, in his direct testimony, Dr. Bartlett stated, "[s]tudies have shown that the shear strength of a given soil type is directly related to the CPT penetration resistance." Bartlett Post Tr. 11822, at 9. Indeed, State Exh. 100 (Eq. 4-1) shows that CPT tip resistance is proportional to, and therefore a measure of, shear strength. State Exh. 100, at 4-55. As Dr. Ofoegbu stated, the CPT measures cone tip penetration resistance, and undrained shear strength is proportional to tip resistance. Tr. 11790, 11810.

4.164. The State asserts that PFS has not engaged in "continuous sampling" of the soils as specified in Reg. Guide 1.132 (State PF ¶ 36). This issue is addressed in Staff PF ¶¶ 4.31 - 4.41. For the reasons stated therein, we find that no further sampling of the PFS soils is required.

4.165. The State refers to a factor (N_K) developed by ConeTec from triaxial compression testing, which the State claims was used by Mr. Trudeau to predict undrained shear strength from

the CPT data. The State urges us to find that the ConeTec N_K factor "is inappropriate for sliding calculations and likely overestimates the available shear resistance provided by the clayey soils." State PF ¶ 47.[15] We decline to do so. The State has pointed to no calculation in which Mr. Trudeau relied upon this factor in any sliding calculations, and we are aware of no such use. Rather, the record shows that Mr. Trudeau cited this factor as providing corroborative evidence that the Layer 1B soils constitute the weakest soil layer at the site. The value of shear strength obtained using the N_K factor determined by ConeTec is consistent with the value of shear strength obtained from PFS laboratory test data. Tr. 11961-62. Accordingly, we see no reason to fault Mr. Trudeau's use of the N_K factor in this manner.

2. <u>The Use of Cement-Stabilized Soil.</u>

4.166. The State correctly points out that the Applicant's soil cement testing program is described in its SAR and in the ESSOW between Stone & Webster and AGEC. *See* State PF ¶ 74; Staff PF ¶¶ 4.74 - 4.83, 4.99. The Applicant has described the design criteria to be verified through these tests, as well as the testing that will be performed. The State is correct that PFS has not identified the bonding materials it will use at the interfaces between the cement-treated soils and the overlying pads or underlying soil, or between various lifts of the cement-treated soil. State PF ¶ 86. However, as the State notes (State PF ¶ 88), the SAR states that the interface bond testing will include direct shear tests (see PFS Exh. JJJ, at 2.6-111, 2-6.118); and the criterion for establishing the shear strength for the various interfaces has been defined.[16] Accordingly, we find no reason to require PFS to identify the material it will use to achieve the specified interface bonds at this time, in that the bonding criteria and test methodology have been sufficiently identified.

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[15] This matter is discussed in Staff PF ¶¶ 4.45 - 4.46.

[16] In this regard, the direct shear tests must show that any failure would occur through the "parent" material (*i.e.*, the cement-treated soil, soil cement, or soil), rather than through the interface. Tr. 10910-11.

4.167. The State also claims that construction activities or removal of the overlying soils may cause the underlying soils to lose strength, casting doubt on the utility of the undrained shear strength values obtained by PFS in its test/sampling program. For this reason, the State urges us to find that "the samples of the upper Bonneville clays that PFS has used for testing may not be representative of actual field conditions" (State PF ¶ 92). We find no basis to do so. We would expect that any major construction project that ensues over a protracted period will encounter field conditions that differ from the conditions experienced during a pre-construction testing program. PFS has not discounted that potential; indeed, it has committed to utilize construction practices with field quality control requirements that take this potential into account. *See* Staff PF ¶¶ 4.95, 4.141 - 144; Trudeau/Wissa Post Tr. 10834, at 34, 36;PFS Exh. JJJ at 2.6-118 - 119. Also, PFS stated that it intends to demonstrate at the start of construction that the techniques it allows the contractor to use will not have an adverse impact on the strength of the soils; there are a number of construction techniques available to prevent damaging the native soils beneath the pads, and PFS stated that it intends to use appropriate measures to prevent such damage. Trudeau/Wissa Post Tr. 10834, at 36-37. With respect to potential damage due to exposure to the elements, this will be minimized through the use of proper construction procedures, scheduling, and measures such as the removal of excess moisture from the soil. *See id.* at 36; Staff PF ¶ 4.144.

4.168. With respect to other "uncertainties" raised by the State (*see* State PF 93-97), it is entirely speculative that these would materialize during construction. Further, while the State would require a showing of "elaborate and detailed specifications . . . for the contractors to follow," we find that the level of procedural detail sought by the State is unnecessary prior to licensing. PFS has identified the design criteria which it must satisfy in the construction of its facility. We see no reason to require an identification of specific construction procedures at this time, because those procedures will not change the applicable design criteria. Further, PFS' construction activities will

be subject to quality assurance/quality control ("QA/QC") procedures as part of its QA program, providing assurance that its design criteria will be satisfied. Tr. 10966-69 (Wissa); Staff Exh. C, Ch. 12 (Quality Assurance). Moreover, construction of the facility will be subject to the QA/QC requirements set forth in 10 C.F.R. §§ 72.140 - 72.176; and the Applicant's construction activities will be subject to NRC Staff inspection. *See* 10 C.F.R. § 72.82; Tr. 10947 (Ofoegbu); Tr. 10958-59 (Staff Counsel). Thus, we need not resolve now any potential "uncertainties" that may arise in the construction process.

4.169. The State points out that cement-treated soil "will continue to cure with time," and it contends, therefore, that "PFS may initially need to achieve a Young's modulus much lower than 75,000 psi to obtain a 75,000 psi modulus over time," perhaps "as low as 40,000 psi." State PF ¶ 100, *citing* Tr. 11216-18, 11222 (Mitchell). However, the State omits mention of the facts that strength and modulus increase at a decreasing rate over time; that most of the gain in Young's modulus occurs within 28 days; and that testing is typically done at 28 days. Tr. 11226-28 (Mitchell). Further, PFS witness Dr. Wissa is well aware that the modulus changes as a function of time, and would take account of this phenomenon in planning a test program and developing the proper mix of soil cement. Tr. 11240-43. Moreover, as Dr. Mitchell stated, testing could establish the rate of strength gain as a function of time, Tr. 11221; and while he opined that the initial dynamic Young's modulus may need to be as low as 40,000 psi, the evidence indicates that this value can be achieved with a compressive strength of 40 psi. Tr. 11221-22 (Mitchell), Tr. 11023, 11025-26, 11028-29 (Ofoegbu). *See* Staff PF 134-136.

4.170. The State asserts that its evidence casts "significant doubt on the value ascribed to Young's modulus and how it may change over time" and "whether testing done under dynamic or static loads will also change the outcome of the moduli." State PF 103. According to the State, because the modulus testing will be done at some time in the future, "it will likely require an

exercise of discretion on the part of the Staff to determine whether PFS has, in fact, met a 75,000 psi over time and under dynamic loading conditions." We do not share this view. As noted above, State witness Dr. Mitchell recognized that testing of the material can establish the rate at which the modulus will increase over time. Accordingly, no subjective judgment need be exercised by the Staff as to whether the necessary Young's modulus of 75,000 psi has been achieved.

4.171. The State presents certain arguments in its proposed findings concerning Part C of this contention, pertaining to the potential for pad-to-pad interaction. *See* State PF ¶¶ 121-124. For example, the State contests the Applicant's view that during an earthquake the soil/cement-treated soil/soil-cement/pad system will act as an integrated unit; in contrast, it claims that the pad and adjacent soil cement will act out of phase, and that the soil cement "will act as a strut and pick up the dynamic load and transfer it laterally." State PF ¶ 121. These concerns are more appropriately addressed in Part D of this contention, as the State recognizes (*see* State PF ¶ 135). Nonetheless, we note that the State fails to address the fact that the soil cement between the pads will tend to crush if one pad moves in the direction of another. *See, e.g.*, Pomerening/Ofoegbu, Post Tr. 6496, at 22; Tr. 11225-26 (Mitchell), 11313, 11355-56 (Bartlett). The soil cement therefore would not transfer significant loads in a lateral direction. Pomerening/ Ofoegbu, Post Tr. 6496, at 21-22. This issue is discussed in the Staff's proposed findings concerning Part D of the contention. *See* Staff PF ¶¶ 5.80, 5.125, 5.131, 5.150, and 5.184.

4.172. In its proposed conclusions of law, the State challenges the timing of the Applicant's soil-cement testing, and asserts that such testing must be accomplished prior to licensing. State PF ¶¶ 125-130. This issue is addressed in Staff PF ¶ 4.13, and 4.94 - 4.100. In our discussion of this matter, we discussed the "one-step licensing procedure" that the Commission has established for ISFSIs in 10 C.F.R. Part 72, and stated our view that tests which verify whether an ISFSI applicant has satisfied its design commitments may be performed post-licensing where, as here,

the tests and the criteria to be satisfied have been clearly defined, and the test results may be verified objectively. *See* Staff's Findings at 31 n.31, and cases cited therein.[17]

4.173. The State cites *Consumers Power Co.* (Midland Plant, Units 1 & 2), ALAB-315, 3 NRC 101, 109 (1976), for the proposition that a nuclear power plant construction permit holder (as the party most likely to be in possession of the facts), has the burden of proving that its nuclear power plant is being built in conformity the Commission's safety regulations. State PF ¶ 128. While we do not disagree with this general proposition, we find that it does not preclude our adherence to the well-established principle that the Staff may be relied upon to perform post-licensing verification of test results, where the design criteria and testing program have been described, and verification of the test results essentially involves a ministerial task.

4.174. The State cites *Consumers Power Co.* (Midland Plant, Units 1 & 2), CLI-74-3, 7 AEC 7, 11 (1974), for the proposition that the Commission's inspection system "is not designed to and cannot assume" the task of detecting the numerous deficiencies that may arise during construction. State's Findings at 66 (PF ¶ 130). The State's reliance on this statement is misplaced. To be sure, the Commission's inspection system does not require NRC visual observation of each step in the construction process at an ISFSI. Instead, the Commission's regulations place responsibility on

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[17] In PF ¶ 129, the State urges us to find that "the level of judgment that would be required of the Staff during its inspections and in its review of PFS's testing program is inappropriate, and that judgment is more appropriately exercised in the course of licensing." State's Findings at 65. In support of this argument, it states as follows:

> Potential defects could occur in the cement-treated soil that will be placed under the 500 pads because of the yet to be achieved cement-treated soil properties and bonding from samples tested in the lab, the construction techniques used to implement the PFS soil cement program, and the fact that the cement-treated soil will be subgrade and only be visible during construction. Tr. (Ofoegbu) at 6591, 6650.

Id. The transcript citations provided by the State do not support this statement -- nor have we been able to find any other place in the transcript that such testimony was given by Dr. Ofoegbu. We therefore reject the State's assertion as unsupported.

a licensee to conduct its construction activities in an acceptable manner; to adhere to its licensing commitments and design criteria; and to correct, as necessary, any significant defects in construction.[18] In addition, licensees are required to follow an approved QA/QC program, and to abide by the Commission's QA/QC requirements. Their performance is evaluated by NRC inspectors, who have the authority to review the Applicant's construction and QA/QC documentation, to interview site personnel, and to observe the construction in progress during their site visits. Thus, the fact that the NRC inspection process "is not designed to and cannot assume" the task of detecting the myriad of deficiencies that may arise during construction fails to establish any reason why the Staff may not be entrusted with the task of verifying the results of the Applicant's test program following the issuance of a license.[19]

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[18] The *Midland* decision, cited by the State, supports this view. Contrary to the State's suggestion, the Commission did not state that the Staff may not be relied upon to conduct inspections but, rather, it emphasized that a licensee bears the responsibility, in the first instance, for the quality of its construction. This is made clear in the very paragraph cited by the State, where the Commission stated:

> [T]here may be thousands of individual cadwelds in the bars reinforcing the concrete base slab and walls of a structure housing a nuclear reactor. The implication of the [licensee's] quoted statement [that the cadwelds were available for inspection] seems to be that the AEC inspectors can inspect, if necessary, virtually all of these cadwelds before they are covered with concrete. Our inspection program is not designed to and cannot assume such tasks. Rather, we require that licensees themselves develop and implement reliable quality assurance programs which can assume the major burden of inspection. . . .

Midland, supra, 7 AEC at 11; emphasis added.

[19] Although NRC inspection practices are not at issue in this proceeding, we recognize (a) that the Staff will conduct inspections of the PFS ISFSI during construction, *see* Tr. 6647 (Ofoegbu); 10947-57, 10958-61 (statements by Counsel); and (b) a formal inspection program exists. *See generally,* NRC Manual Chapter 2690, "Inspection Program For Dry Storage of Spent Reactor Fuel at Independent Spent Fuel Storage Installations" (Dec. 3, 2001), and Appendix B thereto ("Inspection Program For an ISFSI Located Away From Any Reactor Site").

D. Unified Contention Utah L/QQ, Part D

5.190. The State identifies various regulations and regulatory guidance documents which it contends govern the Board's consideration of this portion of the contention (State's Findings at 67-68). Among the listed references is "NUREG-1617, *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel* (March 2000)" -- a document which was not discussed in this proceeding and which, on its face, does not appear to be applicable herein.[20]

5.191. The State contrasts the PFS ISFSI design with the proposed design for an ISFSI at the Diablo Canyon nuclear plant in which the casks would be anchored. State PF ¶ 144. We are unable to draw any useful inferences or conclusions from this comparison. The Diablo Canyon design is not before us, nor do we have jurisdiction to consider the adequacy of that design in this proceeding. Moreover, we do not know even if the Staff or Commission will ultimately approve that design, as it is only in the early stage of review at this time. Tr. 6104, 6532, 6543, 6639, 6733-34.[21]

5.192. The State advocates the use of shake table testing to verify the results of the Applicant's and Staff's casks stability analyses. *See* State PF ¶¶ 151 - 156. In this regard, the State asserts that Staff witness Dr. Vincent Luk "was of the opinion that a shake table test would be useful in confirming his analysis," and "because of the uncertainties in nonlinear analysis there is an incentive to push for such testing." State PF 154, citing Tr. 11569, 11572. The State claims that Dr. Luk later "equivocated somewhat" on the use of shake table tests, by stating that he "confessed that if questionable output data were obtained from shake table testing, then it would

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[20] The State omitted reference to at least one applicable guidance document, *i.e.,* NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems" (January 1997)"; and it incorrectly cited NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities" (March 2000). *See id.* One other correction is in order: Contrary to the State's understanding, Staff witnesses Ofoegbu and Pomerening are affiliated, respectively, with the CNWRA and SwRI. *Compare* State PF ¶ 143 *and* Pomerening/Ofoegbu, Post Tr. 6496, at 1.

[21] Further, we do not understand the State to be arguing in favor of anchoring the casks to the pads at the PFS site. As Dr. Bartlett recognized, that could introduce other concerns. *See* Tr. 10291-92.

be of no use. Tr. (Luk) at 11680–81." *Id.* [22] We find no evidence of "equivocation" by Dr. Luk. The evidence establishes that there is only one shake table in existence at this time (located in Japan) that is capable of handling an object of the size of the Holtec cask; however, that shake table has been found to produce poor results, and therefore is unlikely to be useful in verifying his analysis. Tr. 11654-55, 11680-81. Moreover, while a new shake table facility that could handle a full-scale HI-STORM storage cask is expected to be built in San Diego, that facility will not be completed until at least Spring 2003. Tr. 11570, 11572. Whether or not that facility would be able to conduct useful testing of the HI-STORM cask is as yet unknown. Therefore, we are reluctant to require that the HI-STORM cask be subjected to shake table testing, using PFS ground motions and soil-structure interaction data, as a prerequisite to licensing the PFS Facility. Moreover, based on the Applicant's calculations and the cask stability analyses that have been conducted by the Applicant and Staff, we are satisfied that such testing is not necessary here.

5.193. The State faults Holtec for not performing scale-model shake table testing of the HI-STORM cask during the Staff's review of the HI-STORM generic CoC application, citing a November 1997 letter from Dr. Singh to PFS, in which he indicated that the Staff was interested in such testing. State PF ¶ 155; State Exh. 197A. However, regardless of whether the Staff was once interested in shake table testing of the HI-STORM cask, it is clear that the Staff approved the CoC without requiring that such testing be conducted, *see* Staff Exh. FF (HI-STORM CoC); further, the Staff has not required shake table testing of the HI-STORM cask in connection with the PFS ISFSI application. We therefore cannot find that Dr. Singh's November 1997 letter establishes a basis to require that such testing now be conducted.

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[22] We note that Dr. Luk did not specifically refer to a "nonlinear" analysis; and his statement that there was an incentive to push for shake table testing was not related specifically to the PFS ISFSI. *See* Tr. 11572.

5.194. In its Proposed Findings, the State further asserts that without shake table testing, "what the Board is left with is Holtec's design calculation and engineering judgment." State PF ¶ 157. The State, however, blurs the distinction between "design calculation" and analyses on the one hand, and "engineering judgment" on the other. Here, it is indisputable that PFS presented detailed calculations and quantitative analyses in support of its application. Indeed, the witnesses for both the Staff and the State devoted much of their efforts in this proceeding to evaluating those calculations and analyses. In contrast, little concern was voiced by the State in connection with the use of "engineering judgment" by PFS' experts. Moreover, we find no reason to conclude that the Applicant's use of engineering judgment "lacked any explanation or reasons," or that it failed to provide "sufficient information pertaining to the details of the analysis to permit the correctness of the conclusion to be evaluated." *Id.* Accordingly, we find no reason to disregard its analyses as unsupported.

5.195. The State contends that the walls of the HI-STORM cask are about 30 inches thick, consisting of "concrete encased within a thin inner and outer steel layer." State PF ¶ 161. The Holtec witnesses described the 30 inch-thick walls of the overpack as including a 0.75" thick outer steel shell and a 1.25" thick inner steel wall. Singh/Soler, Post Tr. 5750, at 10; *see* Staff Exh. W.

5.196. In its proposed findings on Part D of the contention, the State included a discussion of transfer operations and the time that would be involved in transferring the MPC from a shipping cask to a storage cask. *See* State PF ¶¶ 165-168. These matters relate to Part E of the contention, and are addressed in Staff PF ¶¶ 6.50 - 6.52. Nonetheless, we note that the estimated transfer operation times take into account actual times experienced in transfer operations involving the HI-STORM 100 casks. *See* Tr. 9013-14, 9046-47, 9079-80. As stated in Staff PF ¶¶ 6.50 - 6.52, we are satisfied that the transfer times represent a conservative estimate of the actual times that would be required for such transfer operations. *See also* Tr. 9034-35, 9041, 9043-44.

5.197. The State asserts "there is no regulatory prohibition on the MPC remaining for a long period, such as overnight, in the unsealed HI-TRAC transfer cask." State PF ¶ 167, *citing* Tr. 9077-78 (Lewis). The cited statement is not quite correct. To be sure, NRC regulations do not explicitly address the amount of time in which SNF may remain within a transfer cask; however, the regulations do impose safety requirements on the storage of SNF, such that the design of SSCs important to safety must be compatible with site characteristics and be able to withstand postulated accidents and the effects of natural phenomena, including earthquakes. *See* 10 C.F.R. § 72.122(b). These requirements pertain to the HI-STORM 100 storage cask system, including the HI-TRAC transfer cask. *See* Staff Exh. FF (CoC, at 1). Mr. Lewis' testimony is not inconsistent with this regulatory framework. He testified that overnight, when transfer operations are not in progress, the MPC would be contained within the shipping cask or the storage cask, with its lid in place, *i.e.*, in its licensed configuration with the capability to withstand earthquakes. Tr. 9073-74. He further stated that he was not aware if the SAR contained this statement, and did not recall if PFS had made this a commitment in the PFS licensing documents. Tr. 9077-78.

5.198. The State asserts that "there is a hesitancy to model the nonlinear behavior of a soil beneath a foundation system based on an untested design or reliance on a nonlinear analysis, such as the one performed by Holtec." State PF ¶ 177, *citing* Tr. 10301-02. This statement, however, represents the opinion of Dr. Bartlett, alone; indeed, in the cited testimony he stated, "that's my perspective on this issue. I would be very hesitant . . ." Tr. 10302. No such hesitancy was expressed by the expert witnesses who testified on behalf of PFS and the Staff. Moreover, if we were to accept Dr. Bartlett's view, a structure or facility could never be built unless it utilized a design whose performance was shown through "years of judgment and precedence." *Id*. We do not share this concern, in that this approach would preclude any "unprecedented" or "unproven" design from ever being approved. *See* Staff PF ¶¶ 4.86 - 4.93, 5.29, 6.35.

5.199. The State contends that Holtec's cask stability analysis used, as inputs, the earthquake time histories and dynamic soil properties developed by Geomatrix; that the Geomatrix ground motion time histories "are in the free field, *i.e.*, away from the influence of the storage pads, the casks and the soil cement"; and that the 0.7g peak vertical and horizontal ground acceleration estimated by Geomatrix therefore "does not include any effects on ground motion from the underlying soils or overlying structures." State PF ¶ 179. While we do not disagree with these general statements, we find no error in this approach. Geomatrix followed the guidance in NUREG-0800 in developing the time histories for the PFS site; and it developed three sets of soil properties (best estimate, lower range and upper range), to represent the stiffness, mass, and energy dissipation characteristics (damping) of the foundation soils during design earthquake shaking, consistent with ASCE-4-86. Youngs/Tseng, Post Tr. 5529, at 4-9. This modeling provides an accurate representation of the lowest frequency of response of the storage pads, and therefore accurately predicts the maximum displacement of the pads. Pomerening/Ofoegbu, Post Tr. 6496, at 24. The Applicant's use of the Geomatrix time histories is acceptable. *Id.*, at 26-27.

5.200. The State further asserts that "there is no record in Holtec's calculation of computation of seismic load without cask sliding." State PF ¶ 180, citing Tr. 10291-92 (Ostadan). However, PFS did consider a number of different cases in its analyses, including runs with a coefficient of friction of 0.8 -- which represents the case for limited cask sliding, as Dr. Ostadan recognized. Tr. 10408. We find that Holtec's use of a range of coefficient of friction values of 0.2 to 0.8 at the interface between the casks and the pads was appropriate, in that the casks are neither anchored to the pads nor immune to the effects of gravity and inertia, and thus an absolute case (in which there is either no potential for cask sliding or no potential for cask tipover) need not have been considered. *See* Staff Exh. C, at 15-31 (0.2 and 0.8 were acceptable bounding values).

5.201. The State describe's Holtec's "cask tipover analysis," in which it determined that "the maximum deceleration of a cask falling onto the pad is a limit of 45 g." State PF 181. The State further asserts that "[a]s part of this analysis," Holtec limited (a) the depth of cement-treated soil under the pads to a maximum of two feet," (b) the modulus of elasticity of the cement-treated soil "to be no more than 75,000 psi," and (c) the concrete storage pad to a maximum thickness of three feet. *Id.* These statements blur the distinction between Holtec's hypothetical cask tipover analysis, performed as part of its application for a generic CoC (*see* Staff Exh. FF, CoC SER at 11-5), and its subsequent PFS site-specific analysis, in which it determined that a cask tipover at the PFS site would not result in a deceleration greater than the 45 g value stated in its generic tipover analysis. *See* Staff Exh. C, at 5-6, 5-30, and 15-8.

5.202. The State asserts that "PFS relies entirely on cask sliding as a mechanism to reduce seismic loads." State PF ¶ 183, *citing* Bartlett/Ostadan, Post Tr. 7268, at 5. Similarly, it asserts that PFS relies on the Holtec nonlinear analysis, and takes "full credit for reduction of seismic forces to the foundations resulting from sliding of the casks atop the pads." State PF ¶ 186. These assertions are not consistent with the evidence. Much of the testimony in the evidentiary proceeding concerned the adequacy of the Applicant's design to resist earthquake loads, wholly apart from the question of cask sliding. While the PFS design does not preclude cask sliding, and such sliding would limit the loads that are transmitted by the casks to the storage pad, *e.g.,* Tr. 10408, it is not correct to conclude that the design "relies upon" the potential for such sliding to occur in the event of a design basis earthquake at the facility.

5.203. The State asserts that the PFS seismic design entails "conflicting requirements" in that the storage pads must be rigid, but not so rigid as to result in unacceptable decelerations in the event of cask drop or tipover; and, likewise, the cement-treated soil under the pads must be stiff enough to provide resistance to pad sliding, but not so stiff as to pose unacceptable

consequences in the event of a cask drop or tipover. State PF ¶ 188. However, the State omits reference to its experts' testimony that these "conflicting" requirements can be resolved by the use of appropriate materials, and testing can show whether or not these requirements have been satisfied. *See* Tr. 7451-52, 10276-82, 10399-401.

5.204. In its proposed findings, the State emphasizes the importance of considering soil-structure interaction effects in seismic design, and it asserts that the Geomatrix soil column analysis, used to obtain free-field strain-compatible soil properties, used the SHAKE program and therefore did not include the effects of soil-structure interaction. State PF ¶¶ 7, 198-200. We do not discount the importance of considering SSI effects in the seismic design of a facility. However, we are unable to find that the Applicant's analysis of the storage pads was deficient.[23] In this regard, we find that Holtec's representation of the soil properties under the pads, using soil springs and dampers, constitutes an acceptable procedure and adequately represents the response of the pads on the soil. Pomerening/Ofoegbu, Post Tr. 6496, at 24; *see* Staff PF ¶ 5.121 - 5.123.

5.205. The State asserts that "there is an anomaly between the more than 1 g response in the CTB and 0.7 g response in the pads." State PF ¶ 208, *citing* Tr. 7544-45 (Bartlett/Ostadan). No such anomaly exists, in that consideration must be given to the relationship between the weight of the structures and their footprint areas as well as the differences in the dynamic characteristics of the CTB with respect to the cask on the storage pads. Inasmuch as the footprint of the CTB is considerably larger than the footprint of the storage pads, resulting bearing pressure on the foundations are 1.46 ksf for the CTB and 1.87 ksf for the pads. *See* Staff Exh. C at 2-63 and 2-57. Further, "free field" measurements are, by definition, representative of conditions located at some distance from a structure, and do not represent the values that would exist near the CTB where the values could be affected by the structure's presence. *See* Tr. 6935, 7012 (Luk).

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[23] The State does not contend that the Applicant's analysis of the CTB, performed by Stone & Webster, failed to account for SSI effects. *See* State PF ¶¶ 207, 208, 211.

5.206. In State PF ¶ 209, the State indicates that "the Luk Report is about the only place in the record that comes close to discussing pad accelerations" and, therefore, Dr. Ostadan resorted to Figures 17 and 20b of the Luk Report as an indicator of pad acceleration. Tr. (Ostadan) 10339, 10342-44." This is an improper use of Dr. Luk's report. As indicated in Staff PF ¶¶ 5.32, n.56, the values shown in the "Figures" relied upon by Dr. Ostadan represent impulse loading, single-term damping, and single-point boundary conditions, and do not reflect acceleration values for the storage pads. Further, even if these values represented accelerations, they represent impulse loading and are of very short duration (lasting only micro-seconds before they are reversed), and would not last for sufficient time to load the pad or cask system. *See* Tr. 11563. Dr. Ostadan's reliance on these values is therefore entirely misplaced.

5.207. The State notes that "foundation sliding is a major concern to the State" and that it is optimistic to expect the foundation to remain stable under the large accelerations predicted for the PFS site. State PF ¶ 210, *citing* Tr. 10340 (Ostadan). In this regard, we note that the Staff's SER did not rely on the Applicant's conclusion that the pads would not slide. The Staff stated:

> The applicant also provided a set of analyses that rely on the frictional resistance of the interfaces and the passive resistance of the natural soil at the north or south boundaries of the soil-cement layers to resist sliding of the pads . . . The values of safety factor obtained from the analyses indicate that ground motion from the design-basis earthquake could cause sliding of the pads (or pad-foundation system). The applicant determined that the magnitude of sliding displacement would not exceed about 6 inches . . . and stated that such sliding displacement would not constitute a safety hazard because there are no external safety-related connections to either the pads or the casks. This statement was supported by additional analyses provided by the applicant . . . which also indicate that sliding of the pads would reduce the tendency for sliding or tipping over of the casks.
>
> <u>The staff agrees with the applicant's conclusion that sliding of the pads would not constitute a safety hazard because pad sliding tends to increase the stability of the casks (against sliding or tip over) and there are no safety-related external connections to the pads or casks that may rupture or be misaligned as a result of pad sliding.</u>

> Therefore, the staff concludes that the proposed cask-pad design is acceptable considering the potential for instability resulting from sliding of the pads under dynamic loading, and the information provided in the SAR regarding potential sliding of the pads is adequate for use in other sections of the SAR to perform additional safety analysis and demonstrate compliance with regulatory requirements in 10 CFR 72.102(c, d) and 72.122(b).

Staff Exh. C at 2-60; emphasis added. Thus, while the State would require that pad sliding absolutely be precluded, the Staff focused on the safety consequences of such sliding, and found that pad sliding need not be precluded because it would not adversely affect safety. We find that this approach reflects consideration of the public health and safety, consistent with 10 C.F.R. §§ 72.102 and 72.122(b); and, further, that pad sliding is neither precluded by the Commission's regulations nor necessary to protect public health and safety.

5.208. The State cites a computer run by Dr. Soler, in which compression of the soil cement within a two pad system was modeled and the resulting force transfer was reported to be 1,900 kips. State PF ¶ 217. While the State contends that this large force has not been accounted for in the Applicant's analysis of pad stability (State PF ¶¶ 217, 218, 222), the State fails to address the fact that the soil cement between the pads will tend to crush if one pad moves in the direction of another (Pomerening/Ofoegbu, Post Tr. 6496, at 22; Tr. 11225-26 (Mitchell), 11313, 11355-56 (Bartlett)), and the soil cement therefore would not transfer significant loads from one pad to another in the lateral direction. Pomerening/Ofoegbu, Post Tr. 6496, at 21-22. This issue is discussed *supra*, in Staff PF ¶ 4.171, and in the Staff's initial proposed findings of fact. *See* Staff PF ¶¶ 5.80, 5.125, 5.131, 5.150, and 5.184.

5.209. The State expresses concern that there are no "design calculations for a 10,000-year earthquake." State PF ¶ 223. However, the 10,000-year return period earthquake is a beyond- design basis event, and NRC license applicants are not required to submit "design calculations" for beyond-design basis events.

5.210. In its proposed findings, the State cites testimony by Mr. Trudeau in support of its assertion that "there is a deficiency in the overturning analysis methodology." State PF ¶¶ 223, 226. In his testimony, Mr. Trudeau stated that just before cask sliding has initiated, an overturning moment of 8970 kp/ft would pertain, which is higher than the 2080 kp value used in his analysis; and, further, the factor of safety against overturning is significantly less than that reported on p. 13 of PFS Exh. UU. Tr. 6246-47. As a result, the State, in its proposed Findings, asserts that "the factor of safety against overturning is significantly less than calculated on page 13 of Cal. No. G(B) 04, Rev. 9. Tr. (Trudeau) at 6245-47." The State omits mention, however, of Mr. Trudeau's further testimony -- on the same page of the transcript -- that the factor of safety against overturning "would still be greater than the 1.1 criterion." Tr. 6247. Accordingly, this alleged deficiency in the overturning analysis is of no consequence.

5.211. The State contends that "pad settlement was not considered in PFS's structural design of the pads or in Holtec's cask sliding stability analysis," and that "settlement from differential cask loading could cause dishing or tilting of the pads." State PF ¶ 232, *citing* Tr. 10332-33 (Bartlett). According to the State, Holtec's cask stability analysis is deficient for failing to take such potential differential settlement into account. *Id.* The State, however, fails to take into account the evidence that any such differential settlement would be small, relative to the overall size and geometry of the structure. Settlement due to loading of the casks would amount to a difference of approximately 2 inches between the edge of a storage pad and its center, *see* Tr. 7729 (Lam, J.) -- and this differential settlement would result in a maximum angle of inclination of approximately 0.64 degrees in the 30-foot direction. Tr. 7761-63 (Bartlett).[24] We can find no

[24] Dr. Ostadan stated that he was not familiar with the formula that one would use to calculate the angle of inclination (in contrast, Dr. Bartlett had no such difficulty). Dr. Ostadan claimed that the "dishing" or 2-inch differential settlement at the center of a pad (caused by loading of the casks) would be greater if the downward pull exerted by an adjacent pad is taken into account. *See* Tr. 7763-72. In this regard, Dr. Ostadan recognized that the additional settlement (continued...)

basis in the record to conclude that a 0.64 degree angle of inclination would present a significant impediment to sliding of the casks on their storage pads. *See* Pomerening/Ofoegbu, Post Tr. 6496, at 18-20; Tr. 6504-06 (Pomerening) (considering the overall geometry of the pad, a small deflection of the pad due to pad flexing, non-vertically propagating waves, or deformation due to cold bonding, would not restrain cask sliding).

5.212. The State asserts that "PFS's estimations of pad settlement have spiraled downward from an initial five inches of settlement, to two inches to finally, in rebuttal testimony, half an inch." State PF ¶ 233. The State fails to observe that the initial estimate of five inches of settlement concerned an earlier design, since abandoned, that was quite different from the design now before us -- for example, in that design the pad was to site on a 4-inch mud mat, rather than the current 2-foot cement-treated soil layer, and the cask loading sequence appeared to "maximize differential settlements." State Exh. 211; Tr. 11314-15, 11343-48 (Bartlett). Second, while the State claims that two inches of settlement was predicted in the SAR, *Id., citing* State Exh. 168, Revision 22 of the SAR shows a total of 1.7 inches of static settlement was predicted for a fully loaded pad with eight casks (including 0.5" elastic, 0.8" primary consolidation, and 0.4" secondary compression settlement). State Exh. 168 (SAR), at 2.6-50.[25] Contrary to the State's understanding, Mr. Trudeau

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[24](...continued)
caused by the adjacent pad (Pad B) would be greatest at the nearby edge of the pad of interest (Pad A), as compared to the center of Pad A. Tr. 7767 (Ostadan). Therefore, the edge of Pad A would settle more, relative to the center of the pad, thus decreasing the total differential settlement between the center and the edge of the pad. Dr. Ostadan's attempt to argue, to the contrary, that the total differential settlement would increase was illogical, and contrary to "elemental geometry." Tr. 7770 (Farrar, J.). Further, his refusal to concede this flaw in his reasoning was most puzzling -- and casts doubt on his objectivity and the weight to be afforded his testimony.

[25] The Staff's SER considered a value for static, post-construction settlement of the pads of "not more than about 3 inches." Staff Exh. C at 2-59. The SER further indicates that dynamic compression of the soil in a design basis earthquake would result in additional settlement of approximately 1.2 inches, as an upper-bound estimate. *Id.* On this basis, the Staff's testimony indicated that the estimated total settlement from combined static and dynamic loading from the design basis 2,000-year earthquake is about three to four inches for the pads (as well as the CTB).
(continued...)

did not retract the Applicant's estimate of long-term settlement; rather, his testimony indicates that the long-term settlement value of "approximately 1.75 inches" was calculated using "conservative assumptions", resulting in "an upper-bound estimate of the settlement"; using more realistic assumptions, he stated that the actual long-term settlement would likely be approximately ½ inch. Trudeau Rebuttal Post Tr. 11275, at 4.[26] Thus, there is no basis for the State's criticism of Mr. Trudeau's testimony concerning this matter.

5.213. The State asserts that "in geotechnical practice a few inches of settlement is a significant number in foundation design." State PF ¶ 236, *citing* Tr. 7501 (Ostadan). However, despite their testimony that "two inches" of settlement is significant in geotechnical practice, neither Dr. Bartlett nor Dr. Ostadan was aware of how much settlement is considered to be allowable for nuclear structures. Tr. 7750. Moreover, the record shows that other nuclear facilities have experienced settlement of several inches, Trudeau Rebuttal, Post Tr. 11275, at 5; and the U.S. Army Corps. of Engineers has published guidance suggesting that up to one foot of settlement may be permissible for other types of structures, *i.e.*, reinforced concrete foundations supporting smokestacks, silos and towers. Tr. 7744-47 (Ostadan). Thus, we cannot find that 1.7 inches of predicted settlement is unacceptable.

5.214. The State also asserts that "given Holtec's assumptions of a perfectly smooth surface for point to point contact on the bottom of the cask, what is important is the relative distribution of the settlement and the angle of inclination of the pad, and how they impact sliding and the inertial forces transferred to the pads and foundation." State PF ¶ 236, *citing* Tr. 7763-64 (Ostadan). In addition, the State asserts that "[a] pad with a dish shape will have an effect on cask

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[25](...continued)
See Pomerening/Ofoegbu Post Tr. 6496, at 10 and 30; Staff Exh. C, at 2-59 and 2-63.

[26] The State asserts that it "agrees that two to three inches of settlement is a reasonable estimate of total settlement." State PF ¶ 236. In fact, Dr. Bartlett testified that the State does not "make a big issue" about the predicted value for settlement of 1.75 inches. Tr. 11349.

sliding depending on whether the cask is climbing up the slope (harder) or down the slope (easier). Tr. (Ostadan) at 7501-02." State PF ¶ 238. These assertions are surprising, given the small (0.64) angle of inclination that may be present due to differential settlement of a pad, and the fact that Dr. Ostadan conceded that he did not know how to compute the angle of inclination. *See* Staff PF ¶ 5.211 and n.24, *supra*. Moreover, there is no basis for the State's assertion that PFS assumes a "perfectly smooth surface" for contact between the casks and the pads. As stated by the Staff's witnesses:

> [T]he Applicant's calculation (Holtec Report No. HI-2012640) assumes a bounding set of coefficients of friction of 0.2 and 0.8 in the analysis of the response of the casks on the storage pad. These values effectively cover the range of friction coefficients that will be present for the steel-to-concrete interface for the contact area between the cask and the storage pad. Friction arises on a microscopic scale because of the roughness and interactions of the surfaces. In addition, friction depends only on the magnitude of the force normal to the surface, and does not depend on the contact area between surfaces. The coefficients of friction utilized by the Applicant represent an average of the values that may be present over the contact area between the cask and the storage pad. Within the overall contact area, there may be regions with different local coefficients of friction. However, when averaged over the entire contact area, the composite is a coefficient of friction that is representative of the bounding values used in the Applicant's calculations (Holtec Report No. HI-2012640).

Pomerening/Ofoegbu Post Tr. 6496, at 22-23; see also, Staff Exh. C at 5-17. We find this is sufficient for use in predicting cask behavior, considering the range of coefficients of friction utilized in the Applicant's analysis.

5.215. The State contends that "there has been no dynamic analysis of the interaction of the soil cement with the CTB mat foundation for the 2,000-year design basis earthquake." State PF ¶ 242, *citing* Bartlett/Ostadan, Post Tr. 7268 at 21. This assertion ignores the fact that the dynamic analysis of the CTB was a lumped mass model with springs representing the soils, and that the analysis did not include the restraint against lateral motion provided by the soil-cement

surrounding the CTB. This was conservative, in that the resulting motion of the CTB would be greater based on this assumption. *See* Pomerening/Ofoegbu, Post Tr. 6496, at 35. Further, while the State contrasts the 1.047 g maximum horizontal acceleration response of the CTB mat with the 0.71g peak free field peak horizontal acceleration response of the adjacent soil cement, it overlooks the fact that the surrounding soil-cement extends out to a distance of approximately 240 feet away from the CTB (or 280 feet on the other horizontal axis), and the difference between these peak acceleration values would not occur at CTB-soil cement interface; rather, the free-field value pertains to a location where it would be unaffected by the CTB structure. *See* Staff PF ¶ 5.205 *supra*. Finally, the State ignores the fact that the majority of the resistance to sliding of the CTB is provided by the soil under the CTB mat foundation that is captured by the perimeter key. Pomerening/Ofoegbu, Post Tr. 6496, at 35.

5.216. The State makes a number of assertions concerning the assumption of rigidity for the CTB. *See* State PF ¶¶ 243, 246. These matters are addressed in Staff PF ¶¶ 5.90 - 5.91, 5.121 - 5.123.

5.217. With respect to cask stability issues, the State asserts that the PFS design has "no redundancies." State PF ¶ 253. The State, however, overlooks numerous conservatisms in the PFS design, such as the fact that the pads may slide without impairing the safety function of the casks; the casks will not tip over under the design basis ground motion, with a significant margin of safety; cask sliding would limit the level of loads transmitted to the pads; and cask tipover would not result in stress levels and accelerations above the allowable 45 g value. A further significant redundancy is inherently provided by the fact that tipover of the casks is unlikely to occur even in a 10,000-year return period earthquake; and finally, cask tipover would not adversely affect public health and safety, in that the dose consequences of such an event would remain within the

10 C.F.R. § 72.106(b) accident dose limits. *See* Staff's Findings on Parts D and E of the Unified Contention Utah L/QQ, dated September 5, 2002.

5.218. The State asserts that Staff witness Jack Guttmann testified that the Staff's "regulatory posture," and the "appropriate standard" for our consideration, is "whether the cask tips over." State PF ¶ 254, citing Tr. 6977. Further, the State cites the Staff's Consolidated SER in support of its claim that the "acceptance criterion" is that "the casks must be stable in the sense that the center of the top cover of the cask must remain within the original contact circle that the cask makes with the pad." *Id., citing* Staff Exh. C at 5-30. Based on these assertions, the State contends that the issue before the Licensing Board "is whether the Applicant has reasonably demonstrated that the HI-STORM 100 cask will not tip over when subject to the proposed design basis earthquake - a 2,000-year earthquake at the PFS site." *Id.*

5.219. The State's assertions in State PF ¶ 254 are incorrect. As the Staff stated in its testimony, and as Staff Counsel reiterated, the issue before the Licensing Board is whether the PFS application satisfies the requirements for ISFSI design stated in the Commission's regulations -- and in particular, whether it satisfies the requirement in 10 C.F.R. §72.122(b)(1), that SSCs important to safety must be designed to accommodate the effects of, and be compatible with, site characteristics and environmental conditions and to withstand postulated accidents, and the companion requirement in § 72.122(b)(2) that the SSCs be designed to withstand the effects of natural phenomena, including earthquakes, without impairing their capability to perform safety functions. *See, e.g.,* Pomerening/Ofoegbu, Post Tr. 6496, at 4-5 (reciting applicable regulations); Tr. 7939 (Turk). Further, as stated in the testimony of Staff witness Michael Waters, the applicable

criterion for consideration is that, in the event of a design basis accident or event, the Applicant's design must not result in radiological doses that exceed the dose limits in 10 C.F.R. § 72.106(b).[27]

5.220. In contrast, the testimony cited in State PF ¶ 254 concerned Mr. Guttmann's discussion of the Staff's initial position that a cask should not tipover -- but it omits mention of his subsequent statement that the Staff could look further and consider the consequences of a cask tipover, if an applicant proposed that approach, Tr. 6977 (Guttmann). Further, the State's citation to the Staff's SER is incorrect, in suggesting that the Staff's "acceptance criterion" was that "the casks must be stable in the sense that the center of the top cover of the cask must remain within the original contact circle that the cask makes with the pad"; rather, this statement described the criterion which had been set by the Applicant in its analysis. *See* Staff Exh. C at 5-30. Contrary to the State's suggestion, this was not an NRC "acceptance criterion."

5.221. Consistent with its assertion that Drs. Singh and Soler stand to reap huge financial benefits from the issuance of a license to PFS, the State asserts that "Dr. Singh admitted that sales to PFS could reach the hundreds of millions of dollars by the 'crudest estimate.' Tr. (Singh) at 5910-11, 5920." State PF ¶ 258. This does not reflect Dr. Singh's testimony in its entirety. Dr. Singh stated that "sales" of Holtec casks to PFS could reach hundreds of millions of dollars, but he noted that other dry cask vendors have gone out of business, and "whether we successfully produce and make money is very different from selling a contract. . . . [I]t's not always a guaranteed

[27] We note that the Staff's evaluation here represents a defense-in-depth approach, in which it, first, evaluated the Applicant's design; second, performed a confirmatory analysis to verify the Applicant's conclusion that the casks would not tipover -- in either a design basis 2,000-year event or beyond-design basis 10,000-year event; and third, performed an independent dose analysis, to examine the radiological consequences of a hypothetical beyond-design basis accident in which all 4,000 casks are assumed to tipover despite all indications that they would not do so. *See* Staff PF ¶¶ 6.191, 6.192.

income." Tr. 5920.[28] The State's assertions concerning the Holtec witnesses' potential bias are discussed above. *See* Staff PF ¶ 1.27, *supra*.

5.222. The State asserts that Drs. Singh and Soler have no experience in conducting nonlinear seismic analyses for free-standing (unanchored) casks, in which the storage pads are supported by soil cement or cement-treated soil, with a "relatively soft clay foundation" at 0.7 g peak ground motions, and that "no prior cask stability analyses, other than those conducted for the PFS site, provide direct, relevant experience in conducting the analysis for this case." State PF ¶¶ 262, 263, 267. Based on this assertion, the State would discount the weight to be given to the analysis performed by Drs. Soler and Singh, on the grounds that it is "unprecedented." *Id.*[29] We can not make these requested findings. The quality of an expert's analysis must be evaluated on its merits, giving due consideration to the expert's qualifications and experience.[30] However, the fact that specific design features or directly analogous site conditions may not have been involved in an expert's previous analyses does not necessarily affect the quality or reliability of the new analysis. Nor could we find that an expert must have analyzed substantially similar applications or designs previously, for that would likely preclude an expert from ever conducting an analysis to

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[28] Similarly, the State asserts that Dr. Singh's testimony indicates that the HI-STORM 100S is a "hugely improved" version of the HI-STORM 100 cask, "to deploy . . . in high seismic regions." State PF 258, n.38. While Dr. Singh did not disagree with this statement, he pointed out that this statement concerned dose consequences to workers -- as opposed to the State's suggestion (*e.g.,* State PF ¶ 262) that the improvement involved cask stability in high seismic sites. *See* Tr. 5912-15.

[29] The State later makes the same argument concerning the weight to be accorded the confirmatory cask stability analysis conducted by Staff witness Dr. Vincent Luk of Sandia National Laboratories. *See* State PF ¶¶ 385, 390, 392, 401.

[30] *See* Fed. R. Evid. 702 ("a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case."). *See also*, *Daubert v. Merrell Dow Pharmaceuticals, Inc*, 509 U.S. 579, 595 (1993) (expert's opinion may be tested, in part, by vigorous cross-examination and the introduction of contrary evidence).

begin with. Further, the fact that a design may be "unprecedented," "unique," or the first of its kind does not render the analytical process incorrect or call into question the quality and reliability of the analysis. *See also* Staff PF ¶¶ 4.87 - 4.93 (soil-cement precedent).

5.223. The State asserts that "Holtec holds its DYNAMO code as proprietary information which has not been provided to the Staff or the State." State PF ¶ 277, *citing* Tr. 5923 (Singh). The State omits reference to the fact that Dr. Singh testified that the DYNAMO code is available to anyone [which presumably would include the State] who is willing to pay for it -- and Holtec has provided detailed information to the Staff concerning the DYNAMO code, in various exchanges between Holtec and the Staff. Tr. 5923-24. Moreover, the Holtec analyses and Drs. Soler and Singh have been made available by the Applicant for deposition and document discovery, as well as extensive cross-examination in this proceeding. Thus, there is no basis for the State's argument that "the Licensing Board and the other parties have had no opportunity to test the reliability and limits of the DYNAMO code due to the proprietary claim held by Holtec" -- or its suggestion that the Licensing Board "would be derelict in the discharge of its responsibilities were it to rest significant findings" on the Holtec witnesses' expert testimony on the grounds that the testimony is "not susceptible of being tested on examination of the witness." State PF ¶ 277, *citing Virginia Electric and Power Co.* (North Anna Nuclear Power Station, Units 1 and 2), ALAB-555, 10 NRC 23, 26 (1979). Similarly, we do not accept the State's suggestion that because "earlier documents" are not in evidence, we may not rely on evidence concerning those matters (State PF ¶ 278), in that the State has had ample opportunities to discover and introduce the evidence it deemed important in this proceeding.

5.224. The State asserts that "Dr. Soler admitted that no document in evidence lists every input value for each of his simulations." State PF ¶ 289, *citing* Tr. 5791, 5796. Even if true, this is irrelevant in that Dr. Soler was made available for discovery and cross-examination, and the

State therefore had ample opportunity to learn of and cross-examine him on these matters. Further, the State fails to note that PFS provided the State and Staff with the inputs for the 11 analytical cases discussed in the testimony of Drs. Singh and Soler, Tr. 6480-81 (Gaukler); and it fails to cite the substantial amount of evidence that was introduced concerning the inputs used in Holtec's analyses. *See, e.g.*, PFS Exh. 225.

5.225. As in the case of the Holtec witnesses' testimony concerning their analyses using DYNAMO, the State challenges the Board's ability to rely on the Holtec witnesses' opinions based on their analyses using VisualNastran. State PF ¶¶ 291-292. In addition, the State cautions that "the visual animations" produced by Holtec "are dangerously prejudicial in that a trier of fact or future tribunal could in fact rely on the animations and not adequately weigh the facts in this case." State PF ¶ 290. We do not share the State's concerns. As in the case of their DYNAMO analyses, the State was able to question the Holtec witnesses in discovery as well as in the evidentiary hearings, concerning their VisualNastran analyses. Further, we are satisfied that both we and the Commission are fully capable of weighing all the evidence in this proceeding, without allowing a visual demonstration to prejudice our views.

5.226. The State asserts that "neither Dr. Soler nor Dr. Singh have proffered evidence that they have prior experience selecting a contact stiffness value for a sliding or tipping analysis of a free standing cask where the ground motions equal to or exceed those for a 2,000-year earthquake at PFS. Tr. (Singh) at 6936." State PF ¶ 301. The cited testimony is that of Staff witness Dr. Luk; it does not support the State's proposed finding recited above, and does not support the State's further proposed finding that the Holtec witnesses did not proffer "evidence that their recommended contact stiffness value has been validated or benchmarked by test data or other cask stability analysis with similar ground motions." *Id.*

5.227. The State challenges Dr. Soler's testimony that Holtec ran an 8 cask simulation for a 2,000-year earthquake "with a contact stiffness of approximately one eighth of 4×10^6 pounds per inch, which resulted in a maximum deflection of cask no 1 of about half an inch to an inch. Tr. (Soler) at 6050-51." State PF ¶ 322. The State urges us to disregard this testimony, on the grounds that "Holtec did not offer supporting documentation for this simulation or the values of all input parameters," and based on the lack of simulation details, "Holtec's reference to this simulation [is] unreliable." *Id.* We decline to make this requested finding. First, we note that the case described by Dr. Soler involved a run with a contact stiffness of 1/8 of 40 million pounds (rather than 1/8 of 4 million). Second, we note that the testimony in question was specifically elicited by the State in its cross-examination of Dr. Soler. The State can hardly be heard to complain that Dr. Soler did not provide further information concerning this matter, when the State itself failed to request it, and there was no indication that Holtec would have been unable or unwilling to provide the data if it had been requested to do so. *See* Tr. 6050-51.

5.228. The State cites the testimony of Dr. Luk in support of its claim that, "based on Dr. Luk's results, soil structure interaction will filter some of the frequencies but still significantly amplify the accelerations when compared to free field acclerations. [sic] Tr. (Khan) at 9511, 9539; (Luk) at 6934-36." State's Findings at 142 (State PF ¶ 324). Dr. Luk's testimony does not support this statement; rather, he indicated only that his analysis showed the presence of a significant soil-structure interaction effect. *See* Tr. 6934-35.

5.229. The State asserts that "Holtec did not proffer an animation where it simultaneously lowered both damping and stiffness," that "Holtec did not run a simulation at a contact stiffness of 1×10^6 pounds per inch," and that "the additional Holtec animations varying either damping or contact stiffness are insufficient to show that the cask behavior is not sensitive at both lower damping and lower contact stiffness, than used in Holtec simulations (*e.g.*, 40 percent damping and

18.8 x 10^6 pounds per inch contact stiffness)." State PF ¶ 334; emphasis added. The State fails to explain, however, why further analyses need be conducted, based on unrealistic parameters that are not physically realizable. *See* Staff PF ¶ 5.62, 5.113, n.52, and n.53, in the Staff's proposed findings of September 5, 2002.

5.230. The State contests Dr. Singh's testimony that "Holtec changed the damping from the 5 percent used in the 2,000-year earthquake DYNAMO runs to 40 percent with the VisualNastran runs because of the increase in ground motion." State PF ¶ 339, *citing* Tr. 9671 (Singh). The State asserts that there is "no evidence beyond Dr. Singh's single statement to support a finding that the impact damping increases with increase in ground motion." *Id.* This is incorrect. In his testimony, Dr. Singh explained that "the percent of critical damping is related to the severity of the event," such that a weak event would involve a small amount of damping, but that "[a]s the severity of the earthquake increases and the structure . . . responds to the earthquake, the . . . impact damping . . . is greater." Tr. 9670. Further, he stated that "[t]he NRC's documents" recognize this with respect to structural damping, in that "[t]he damping permitted for the operating basis earthquake is less than that for design basis earthquake, deliberately recognizing the fact that the extent of damping is directly related to the severity of the event." Tr. 9670-71. Dr. Singh's views are correct, and are supported by § 3.7.1 of NUREG-0800 (Staff Exh. DD), which indicates that the specific percentage of critical damping values used in analysis of Category I SSCs "are considered to be acceptable if they are in accordance with Regulatory Guide 1.61," *id.* at 3.7.1-7; further, "a demonstration of the correlation between stress levels and damping values will be required and reviewed for compliance with regulatory position C.3 of Regulatory Guide 1.61." *Id.* at 3.7.1-8.[31]

[31] Regulatory Guide 1.61, "Damping Values for Seismic Analysis of Nuclear Power Plants," is not in evidence. The Staff notes, however, that Table 1 of that document, entitled "Damping Values (Percent of Critical Damping)," shows larger permissible damping values for nuclear power (continued...)

5.231. The State cites a paper presented by Drs. Singh and Soler in 1998, concerning the HI-STAR 100 storage cask. State PF ¶ 355, *citing* State Exh. 174.[32] In that paper, the authors stated that "[a]fter a certain threshold value, the response (viz. maximum tilting of the cask axis) increases rapidly with increase in the ZPA [zero period acceleration] level." *Id.*, at 15-16. However, the HI-STAR 100 cask system has not been proposed for use at the PFS site, and the State has not shown that the stability of the HI-STAR cask system is comparable to that of the HI-STORM cask system. Further, the State fails to mention Dr. Soler's testimony, in which he described differences in the geometry of the HI-STAR cask and the HI-STORM cask, and stated that the HI-STAR cask is more prone to incipient tipping than the more stable HI-STORM cask. Tr. 6105-07. Thus, there is no basis for the State's criticism of Dr. Soler's testimony, in which he disagreed that the maximum tilting for a HI-STORM cask would increase "rapidly" as the zero period acceleration increases. *See* Tr. 6032, 6036-37.

5.232. The State recites Dr. Soler's view that, to ensure an adequate safety factor to prevent cask tip over, the maximum excursion of the top of the cask should not exceed one-half of the cask radius. State PF ¶ 356, *citing* Tr. 6034-35. The State then proposes its own safety factor, urging that we impose "a maximum allowable rotation angle" of 8.15 degrees from vertical. *Id.; see also* State PF ¶¶ 357, 360. We find no sufficient basis in the record that would warrant the imposition of this proposed requirement, nor do the citations provided in the State's proposed findings demonstrate a satisfactory basis for such a requirement.

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[31](...continued)
plant SSCs under the Safe Shutdown Earthquake than for the Operating Basis Earthquake -- consistent with Dr. Singh's testimony.

[32] Singh, K.P, A.I. Soler, and M.G. Smith, "Seismic Response Characteristics of HI-STAR 100 Cask System on Storage Pads" (January 1998) (State Exh. 174).

5.233. The State cites NRC Regulatory Guide 1.100,[33] which purportedly endorses IEEE 344-1987,[34] in support of its view that shake table testing of the HI-STORM cask should be required here. State PF ¶¶ 362-364, 366. We note, however, that these documents specifically concern nuclear power plant electrical equipment Class 1E components, and nowhere address the need for testing of large free-standing structures such as the HI-STORM 100 casks. Accordingly, the State's (and Dr. Khan's) reliance on these documents is misplaced, in that they are not probative of the State's claim that such testing should be required here. Moreover, the State points to nothing in the Commission's regulatory guidance applicable to dry cask storage systems or ISFSI facilities which endorses this view.

5.234. Nor do we find support in the testimony of Staff witness Dr. Luk, for the State's view that shake table testing should be required. *See* State PF ¶¶ 364, 367. First, we note that the State incorrectly relies upon Dr. Luk's "testimony concerning the availability of a large shake table facility which could accommodate a full scale cask." State PF ¶ 364, *citing* Tr. 15569-72 (Luk). To the contrary, Dr. Luk indicated that no such facility is currently available, and is not expected to become available before Spring 2003. *See* ¶ 5.192, supra; Tr. 11570, 11572. Also, as we stated above, whether or not that facility would be able to conduct useful testing of the HI-STORM cask is as yet unknown. We can find no reasonable basis to delay licensing of the PFS Facility, based upon such speculative and uncertain potentialities.

5.235. Second, the State mischaracterizes Dr. Luk's testimony in stating that "[because of uncertainties in the analysis, Dr. Luk confirmed he and the individuals in 'his group' view shake table testing as 'useful' in confirming <u>his analysis</u>. Tr. (Luk) at 11569, 11572." State PF ¶ 367.

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[33] NRC Regulatory Guide 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants (Draft EE 108-5, Proposed Rev. 2, Aug. 1987).

[34] IEEE 344-1987, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" (Institute of Electrical and Electronics Engineers, 1987).

To the contrary, Dr. Luk's testimony did not address whether he or others in his group believed that shake table testing would be useful in confirming his analysis of the PFS ISFSI; rather, the record shows he was discussing the potential use of shake table testing with respect to the Staff's generic research program, rather than this facility. *See* Tr. 11570-71. Finally, the State mischaracterizes Dr. Luk's testimony, in stating that "Dr. Luk testified that he could 'almost assure [that] the cask will not be damage or destroyed on the shakes table.' Tr. (Luk) at 7111." State PF ¶ 367. In fact, Dr. Luk was describing his efforts to obtain free use of a cask in 1999, approximately three years ago, for use in shake table tests. *See* Tr. 7091-92, 7111. The testimony did not address whether the casks would or would not be damaged in shake table testing at the still-proposed San Diego facility. Thus, there is no basis for the State's proposed finding that "Dr. Luk anticipates a shake table test facility able to conduct full scale tests will be available in the spring," in connection with which the State asserts that Dr. Luk has provided "assurances that a cask would not be damaged by shake table tests." State PF ¶ 376. *See also*, Staff PF ¶ 5.192, *supra.*

5.236. The State contends that contrary to Mr. Guttmann's testimony that "the Standard Review Plans are still applicable to the entire country," Dr. Luk testified as to his understanding that the generic study was initiated because "there is a concern to whether the current Standard Review Plan is adequate to support the . . . licensing review process" in areas with "relatively higher seismic loading in the west." State PF ¶ 377, n. 54, citing Tr. 6838-39. While the State places emphasis on Dr. Luk's understanding of the matter, it fails to recognize that Dr. Luk is not an NRC employee and as such, has only second-hand knowledge of this matter -- whereas Mr. Guttmann, a section chief in the Spent Fuel Project Office, specifically corrected Dr. Luk's testimony, stating that the Standard Review Plan is applicable to the entire United States including "the western United States where high seismic conditions occurs," and Dr. Luk agreed with that correction. Tr. 6839.

5.237. The State would fault the Staff for its alleged "untimeliness" in submitting the Luk report to the other parties. State PF ¶ 378, n. 56. The State fails to note, however, that the cask stability issues to which the Luk report relates were only introduced in this proceeding by our December 2001 decision to admit the issues raised in Utah Contention QQ. *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-01-39, 54 NRC 497 (2001). Further, the Staff then sought to produce the Luk report to the Board and parties as promptly as possible -- producing a summary of Dr. Luk's findings in February 2001, a preliminary (near-final) version of the report on March 8, 2001, and the final report on March 31, 2001. Although we recognize that this late development required additional effort by all parties, we also note that the Staff voluntarily produced substantial documentation related to the report, and made Dr. Luk available for a deposition by the State. Too, we afforded the State an opportunity to conduct additional cross-examination of Dr. Luk, after assuring ourselves that it had been given a sufficient opportunity to review his report. We therefore find no fault in the Staff's actions, and further find that the State was not prejudiced by the timing of Dr. Luk's completion of his report and the Staff's production thereof. *See, e.g.,* Tr. 6880-97, 11612-21.

5.238. The State claims that Dr. Luk's report may be tainted by a potential conflict of interest, in that "a review panel consisting of three NRC Staff and four industry representatives provided technical advice and input to the generic and site specific cask stability studies conducted by Dr. Luk and his associates." State PF ¶ 383, *citing* Tr. 6994-96, 7052-54. Included among the industry representatives were representatives from Southern Company [sic] [Southern Nuclear Operating Co.], San Onofre Nuclear Generating Station, the Electric Power Research Institute, and a private consultant, Dr. Robert Kennedy. Tr. 6995. The State notes that Southern Nuclear Operating Co. and Southern California Edison Co. (owner of San Onofre), are two of the eight members of the PFS consortium. State PF ¶ 383, *citing* Staff Exh. C at 17-1. Further, the State

contends that "fundamental fairness" mandates the "disclosure of all potential conflicts of interest," whether or not a party believes them to be material and relevant to a licensing proceeding; and it asserts that "[d]ue to the lack of disclosure of potential conflicts of interest of the industry representatives on Dr. Luk's advisory panel, compounded by the lateness of the availability of the Luk report to the State, the State has had little or no opportunity to probe the backgrounds of the advisory panel and its influence on the Luk methodology and analysis during discovery." State PF ¶ 384.

5.239. We find no reason for concern that Dr. Luk's report may have been tainted due to this alleged potential conflict of interest. First, based on our observation of Dr. Luk's testimony, including his responses to cross-examination and Board questions, we are fully satisfied as to his candor, objectivity and professionalism. Second, Dr. Luk testified that he did not receive any comments from the review panel prior to completing his preliminary PFS site-specific analysis in October 2001, Tr. 7102-03; and while the review panel was then given an opportunity to review his site-specific analysis, that review did not result in any changes in the report before it was issued in March 2002, other than the manner in which the results were presented and the removal of irrelevant material. Tr. 7103-05.[35] Third, Dr. Luk's testimony is corroborated by the minutes of the three meetings held by the review panel (on Feb. 24-25, 2000, Oct. 31-Nov. 1, 2000, and Nov. 15-16, 2001), which show no improper attempt to influence Dr. Luk's analyses or the outcome of those analyses. *See* Staff Exh. GG. With respect to the State's claim that it has not had a fair opportunity to probe these matters, we note that we have not precluded the State from conducting whatever discovery it considered necessary to probe this matter -- and indeed, we afforded the

[35] The State incorrectly states that Dr. Luk and the review panel met on three occasions "including November 2001, to discuss the details of the PFS model. Id. at 7077-78." State PF ¶ 383. The review panel met to discuss the generic NRC study, as well as the site-specific analyses; the PFS site-specific study was only proposed in May 2001, after two of those meetings had been held, and was discussed only in the November 2001 meeting. *See* Tr. 7082-83, 7102.

State an opportunity to request that Dr. Luk be recalled as a witness, following his initial appearance in the proceeding, after the minutes of the advisory panel were produced by the Staff. *See* Tr. 7254-58, 11581. Thus we perceive no prejudicial unfairness to the State.

5.240. As in the case of the Applicant's witnesses (*see* Staff PF ¶ 5.222 and n.29, *supra*), the State contends that Dr. Luk lacks direct experience in modeling site conditions and facility designs that are relevant to the PFS design or site conditions. State PF 385; *cf.* State PF ¶¶ 390, 392, 401. We reject these arguments for the reasons stated above, in connection with the cask stability analyses performed by Drs. Singh and Soler. *See* Staff PF ¶ 5.222 and n.30, *supra.* Further, for the reasons stated previously, we find that Dr. Luk and his team are quite experienced in conducting finite element analyses of the type conducted here, and that their PFS site-specific analyses provide useful, relevant, and reliable evidence as to the stability of the casks at the PFS facility, in the event of either a 2,000-year design basis earthquake, or a 10,000-year beyond-design basis event. *See, e.g.*, Staff PF ¶¶ 5.179, 5.187.

5.241. The State portrays Dr. Luk as having "no expertise in soil dynamics," and appears to confuse Dr. Luk's testimony concerning his expertise in this area. *See* State PF ¶¶ 388-390. The record does not support the State's view of the testimony. Dr. Luk described the members of his research team and their respective areas of expertise related to his PFS site-specific analysis. Tr. 6765-66. Dr. Luk stated that he is personally not an expert in soil mechanics, but he is very familiar with the dynamic coupling process involved in soil-structure interaction, Tr. 7036-37, 7038; further, he stated that he considers himself to be an expert in conducting soil-structure interaction analyses. Tr. 7037-38. In addition, he obtained input for his analytical model from a member of his team (Mr. Po Lam), who developed the soil foundation model and the deconvolution process that is part of the soil foundation modeling. Tr. 7037. Based on this testimony, as well as our familiarity with Dr. Luk's ability to respond to questions concerning this aspect of this study, we are

unable to adopt the State's suggestion that neither Dr. Luk nor any member of his research team is qualified to model soil dynamics or soil-structure interaction effects. State PF ¶¶ 390, 391.

5.242. Similarly, the State asserts that "Dr. Luk's experience in the nonlinear modeling of the seismic behavior of cylindrical, free standing casks is limited to his generic study and the Hatch analyses," and that he lacks "experience in the nonlinear modeling of the seismic behavior of cylindrical free standing casks supported by cement-treated soil and a relative soft clay foundation at ground motions equal to or greater to the 2,000-year earthquake at PFS." State PF ¶ 392; *see also* State PF ¶ 401. In effect, the State suggests that unless an expert has modeled the same case previously, he will necessarily lack the necessary expertise to ever model that case in the future. We do not share that view. Moreover, Dr. Luk demonstrated considerable experience in modeling cask behavior prior to conducting his PFS site-specific analysis, including the San Onofre high seismic site in which three casks were modeled as tied together. This experience is relevant and useful in assuring the adequacy of his analysis here. *See, e.g.,* Tr. 6987-88. [36]

5.243. The State contends that the Staff directed Dr. Luk to use a coefficient of friction of 0.31 at the interface between the pad and underlying cement-treated soil. State PF ¶ 406, citing Tr. 6924-25. The State fails to note, however, that Dr. Luk also ran other studies using coefficient of friction values for this interface of 1.00. *See* Staff Exh. P, Tables 8, 9 and 10. Further, Dr. Luk ran studies in which he varied the coefficient of friction for the interface between the pads and casks, using values of 0.20 and 0.80. *Id.,* Tables 8, 9 and 10.

5.244. The State also asserts that Dr. Luk was concerned about the increase in computer time that would be involved in modeling the plastic behavior of soils, and that he therefore "used

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[36] In State PF ¶ 398, the State asserts that Dr. Luk's finite element analysis model "has 4,124 elements - 864 elements model the cask, 384 elements model the storage pad, 848 elements model the soil cement adjacent and beneath the pad, and 2,000 elements model the soil foundation. Id. at 7027." This estimate of the number of finite elements in his model was later corrected: Dr. Luk testified that his PFS model actually included a total of approximately 200,000 nodes. Tr. 11523, 11531.

an elastic body to simulate foundation soils. Tr. (Luk) at 11548." State PF ¶ 407. The State fails to note, however, that Dr. Luk stated that the soils behave elastically, that it is common for soils to be modeled as elastic bodies, and that modeling the soils as plastic would not produce differences significant enough to warrant that a plastic modeling be conducted. Tr. 11547-49.[37]

5.245. In its proposed findings, as at the hearing, the State contends that "Dr. Luk treats the interface layers under the storage pad as granular material and models the interface nodes as a frictional material, such as sand." State PF ¶ 409, *citing* Tr. 10530 (Bartlett), and Staff Exh. P, Table 8. These assertions are demonstrably wrong, and reflect a fundamental lack of understanding by the State as to how Dr. Luk modeled these interfaces -- as Dr. Luk clearly explained in his rebuttal testimony. *See* Tr. 11509-16, 11559-61, 11566-67, 11580-81, 11587-89, 11594-95, 11600-05.

5.246. The State further asserts that in using Coulomb's Law of Friction in prescribing values for the interface, Dr. Luk modeled the PFS site in a manner inconsistent with the material properties of the site. State PF ¶ 411-412. This assertion is also incorrect. Dr. Luk indicated that he used the Coulomb's Law of Friction in prescribing values for the interface, and that material properties for the adjacent bodies are not specifically represented; rather, the coefficient of friction describes the relationship of the two adjacent bodies at the interface. *See* Tr. 11509-16, 11559-61, 11566-67, 11580-81, 11587-89, 11594-95, 11600-05. Dr. Bartlett, in contrast, incorrectly used a different equation, the Mohr-Coulomb theory of failure, which has nothing to do with the interfacial condition. See, e.g., Tr. 11601-04.

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[37] The State incorrectly suggests that "[a]s part of the PFS site-specific confirmatory analysis, Dr. Luk also had an eye on developing a practical analytical model that could be used by the nuclear industry," and therefore did not model the soils as plastic. State PF ¶ 407, *citing* Tr. 11549. This testimony concerned the development of Dr. Luk's generic model, which was used as well in the PFS site-specific analysis. *See* Tr. 11548-49.

5.247. The State also asserts that Dr. Luk used incorrect soil properties in his analysis, by using the Geomatrix upper bound, best estimate and lower bound values for the PFS site soils rather than the Stone and Webster "soils characterization." State PF ¶ 415. The State does not explain why it believes that the Geomatrix soil properties are inappropriate for use in modeling the PFS site soils, nor are we aware of any basis for the State's assertion.

5.248. The State cites testimony by Dr. Luk that he did not include the cohesive strength of soils in his model. State PF ¶ 417, *citing* Tr. 6787 [sic]. While Dr. Luk did state that he included only the frictional resistance component of shear resistance in his model, and did not include cohesion, Tr. 6926-27, he further explained that cohesion is a second order effect as compared to frictional resistance. Tr. 6927. On this basis, despite the State's insistence that cohesion is an inherent soil property (*see* State PF ¶¶ 416-420), we find no reason to fault Dr. Luk's analysis.

5.249. Similarly, the State contests Dr. Luk's modeling of the soils as elastic. State PF ¶¶ 424-425. This matter is addressed in Staff PF ¶ 5.244, *supra*. For the reasons stated there, we find no flaw in the fact that his analysis treated soils in this manner, consistent with established analytical practice.

5.250. The State criticizes Dr. Luk's use of a Young's modulus of 270,000 psi for the cement-treated soil under the pads. State PF ¶¶ 427-432. We recognize that this value is considerably greater than the 75,000 psi value which the PFS design must achieve. However, Dr. Luk's analysis is not adversely affected by the use of this larger value. First, we note that the use of this value was conservative, in that it would produce a greater cask response on top of the pads. Tr. 11542-43, 11656-57. Moreover, the use of this value would have little effect on the results of the analysis, as shown by the insignificant effect that results from varying the Young's modulus value for the substantially deeper soils beneath the pads that occurs depending on whether one uses the best estimate, upper bound, or lower bound soil values. Tr. 11543-46,

11657-62; Staff Exh. P, at 10 (Tables 2 and 3), and 30 (Table 8). We therefore do not agree with the State's suggestion that using a Young's modulus of 270,000 psi for the cement treated soil could produce significantly different results (stating that the State's expert "was unwilling to hazard a guess at the effect"). State PF ¶ 431.

5.251. The State challenges Dr. Luk's inclusion in his modeling effort an evaluation of the Pacoima Dam earthquake. State PF ¶¶ 433-439. According to the State, the Pacoima Dam earthquake is not representative of the 2,000-year earthquake at the PFS site. State PF ¶¶ 434, 436, 438. The State, however, misunderstands the purpose for the inclusion of this event in Dr. Luk's report. As stated therein, the Pacoima Dam record was included to provide a "sensitivity" study, not to represent the PFS design earthquake. See Staff Exh. P, at 4 and 39.

5.252. The State contends that the 10,000-year earthquake analyses by Dr. Luk and Holtec produced different quantitative results. State PF ¶¶ 444. According to the State, notwithstanding thefact that the two studies used different models, "the results generated by the Luk analyses provide no assurances that Holtec obtained accurate results." *Id.* We do not view Dr. Luk's work as an effort to verify the "accuracy" of Holtec's results. As stated in the Staff's proposed findings of September 5, 2002, the models used in these two analyses are quite different, and the specific quantitative results produced by the two studies do vary (Staff PF ¶¶ 5.179, 5.187). However, we are satisfied that Dr. Luk's analysis "provides firm support for the conclusion that the HI-STORM 100 storage casks will not tipover or collide" in the event of either the design basis (2,000-year return period) earthquake, the 1971 San Fernando Earthquake, or the 10,000-year return period seismic event. Staff PF ¶ 5.187.

5.253. We turn to consider the State's proposed findings on Part E of this contention.

E. Unified Contention Utah L/QQ, Part E

1. Geotechnical Bases for the Exemption.

6.238. In its description of "Regulations/Guidance" applicable to Part E of this contention, the State cites several references which are either incorrect or not applicable. In this regard, it incorrectly states that 10 C.F.R. § 72.104(a) establishes a 75 mrem dose limit for normal operations and anticipated occurrences (in fact, a 25 mrem dose limit is established for normal operations and anticipated occurrences). *See* State's Findings at 185. In addition, the State incorrectly lists the following documents as applicable regulations or regulatory guidance documents with respect to this portion of the contention (*Id.*):

> (a) "DOE Standard 1020-02" -- a Department of Energy document which, although cited as a reference point in the Staff's SER, has not been adopted by the Commission, *see* Stamatakos/ Chen/McCann Post Tr. 8050, at 21; Stamatakos Rebuttal Post Tr. 12648, at 2; Staff PF ¶¶ 6.100 and n.119;
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> (b) NUREG/CR 6738 -- a document published by an NRC contractor (Risk Engineering, Inc.), which has not been adopted or approved by the agency, Stamatakos Rebuttal Post Tr. 12648, at 8; Tr. 7867-68, 12748-79; and
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> (c) "NUREG-1617, *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel* (March 2000)" -- a document which, as stated above, was not discussed in this proceeding and which, on its face, does not appear to be applicable herein.[38]

6.239. In State PF ¶ 448, the State compares sites in the Intermountain West to sites located in the Western United States near plate boundaries, and asserts that "in the Intermountain West, where the Skull Valley site is located, the situation is complex. Tr. (Cornell) at 7896; Tr. (Arabasz) at 9176-77." The citations provided by the State, however, do not support this assertion, and it should therefore be disregarded.

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[38] The State also incorrectly cited "10 CFR § 106(b)," in place of 10 C.F.R. § 72.106(b), as the applicable standard with respect to accident dose limits, *see* State's Findings at 185; it failed to cite NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Facilities" (March 2000), *id.* at 186; and it incorrectly cited NUREG-1567, "Standard Review Plan for Dry Cask Storage Systems" (January 1997), *id.*

6.240. In State PF ¶ 450, the State asserts that "ISFSI SSCs of concern at PFS (*e.g.*, casks, foundations composed, in part, of soil-cement) are atypical of those at nuclear power plants, for which there is a greater knowledge base. Tr. (McCann) at 8277." However, a review of Dr. McCann's testimony reveals that he was discussing only the lack of "experience" in ISFSI performance, as compared to a nuclear power plant, for use in developing a probabilistic risk assessment (PRA). *See* Tr. 8277. In addition, we see no basis for the State's further assertion in State PF ¶ 450 that "PFS and the Staff are asking the Board to agree with them that the capacity side of the equation will do all the heavy lifting." In this regard, we agree with Dr. Cornell's stated view that both the seismic demand at the PFS site and the seismic capacity of the facility have been the subject of extensive analysis in this proceeding, by both PFS and the Staff. *See* Cornell Rebuttal Testimony Post Tr. 12951, at 3-4.

6.241. The State correctly observes, in State PF ¶ 451, that:

> Under the changes in the NPPs' requirement, codified at 10 CFR § 100.23, a NPP applicant now refers to NRC guidance (Reg. Guide 1.165) where the "reference probability" for determining the SSE from a probabilistic seismic hazard analysis is specified to be that probability which has an annual median probability of 1×10^{-5} of exceeding the SSE, which is equivalent to a mean annual exceedance probability of 1×10^{-4} (or a return period of 10,000 years) for the CEUS; there is the option that an applicant may request and justify the use of a higher reference probability for a site not in the CEUS (*e.g.*, in the western United States). Reg. Guide 1.165 at 1.165-12 (State Exh. 201); Tr. (Cornell) 8001-02.

State's Findings at 189. This is supported by Reg. Guide 1.165, which states as follows:

> However, the final SSE at a higher reference probability may be more appropriate and acceptable for some sites considering the slope characteristics of the site hazard curves, the overall uncertainty in calculations (i.e., differences between the mean and median hazard estimates), and the knowledge of the seismic sources that contribute to the hazard.

State Exh. 201 at 1.65-12; emphasis added.

6.242. Significantly, however, the State fails to observe that the slope of the hazard curve for the PFS site (located in the Western United States), is quite steep. As stated by Dr. Stamatakos, the PFS PSHA seismic hazard curve slopes have "A_R" values of approximately 2.20 to 2.25 (for A_4/A_3), based on the values shown in Staff Exh. JJ, at 5[39] -- which "are within the upper range of A_R values cited in Appendix C of DOE Standard 1020 for sites near tectonic plate boundaries." Stamatakos Rebuttal Post Tr. 12648, at 6.[40] Accordingly, given the slope of the PFS site seismic hazard curve, Reg. Guide 1.165 would lend support to the use of a reference probability for a nuclear power plant at the site that is higher than a MAPE of 1×10^{-4} (*i.e.*, a return period of less than 10,000 years). *See* Tr. 8001-02; State Exh. 201 at 1.65-12.

6.243. In State PF ¶ 454, the State asserts that the mean MAPE for the five nuclear power plants ("NPPs") in the Western United States, discussed in DOE topical report TR-003 (State Exh. 202), does not support a conclusion that the reference probability for a NPP at the PFS site would be a MAPE of 2×10^{-4} (5,000-year return period). According to the State, (a) "at least three of the five NPPs in the survey are located near tectonic plate boundaries along the Western coast, have steep hazard curves, and are not simply representative of the Intermountain area," and (b) the Palo Verde site is "in an area of low seismicity and with a mean exceedance probability corresponding to a 26,000-year return period earthquake,"[41] such that it "is not only an outlier in

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[39] A_R is the ratio of ground motions over a "decade" of exceedance probabilities. Thus, A_5/A_4 is the ratio of the ground motion at a MAPE of 1×10^{-5} compared to the ground motion at a MAPE of 1×10^{-4}, while A_4/A_3 is the ratio of the ground motion at a MAPE of 1×10^{-4} compared to the ground motion at a MAPE of 1×10^{-3}. The PFS A_R values are reflected in the PSHA curves shown in Staff Exh. JJ, at 5. These ground motion values are as follows: (a) 400 cm/s^2 (rock) and 520 cm/s^2 (soil), for a MAPE of 1×10^{-3}; (b) 900 cm/s^2 (rock) and 1150 cm/s^2 (soil), for a MAPE of 1×10^{-4}; and (c) 1480 cm/s^2 (rock) and 1880 cm/s^2 (soil), for a MAPE of 10^{-5}.

[40] As shown in Staff Exh. JJ, at 5, the A_5/A_4 value for the PFS PSHA seismic hazard curves (rock and soil) are approximately 1.60. *See* n. 39, *supra.*

[41] Tr. (Cornell) at 8033;Tr. (Arabasz) at 9177-78, 10096.

the calculation of the sample mean but its MAPE argues against the applicability of a 5,000-year MAPE to the entire WUS." State's Findings, at 190-91 (PF ¶ 454).

6.244. The State, however, cannot have it both ways: Thus, while the MAPE for the Palo Verde plant (3.8E-05/year) is quite low as compared to the other western U.S. sites in the study, this has the effect of reducing the mean MAPE (i.e., increasing the return period) for the collection of WUS plants in the study, in that without the Palo Verde NPP, the mean reference probability would be higher (equating to a mean return period of 4,332 years, instead of the approximately 5,000 year sample mean return period stated in the study). *See* Staff PF 6.78 and n.117; State Exh. 202 at C-18.[42] Thus, the fact that the DOE TR-003 study includes the Palo Verde plant lends support to the view that the mean reference probability for NPPs in the entire Western United States -- including those which are not located near tectonic plate boundaries -- is approximately 2×10^{-4} (5,000-year return period). *See* Staff PF 6.78 and n.118; Stamatakos Rebuttal Post Tr. 12648, at 4.[43]

6.245. In this regard, we note that the State, itself, concedes that "the 5,000-year MRP may justifiably apply at WUS NPP sites where there are steep hazard curves, such as near tectonic plate boundaries" -- although it claims that a 5,000-year MRP "does not necessarily apply in the

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[42] Two of the five plants (Diablo Canyon and San Onofre) are located near tectonic plate boundaries. A third plant (WNP-3) is located further away from a tectonic plate boundary; its seismic hazard curve is dominated by earthquakes resulting from the subduction of the Juan de Fuca plate beneath the North American plate. The other two sites (Palo Verde and WNP-2) represent inland sites that are not situated at a plate boundary and whose seismic hazard curves are directly controlled by earthquakes generated by local crustal faults. *See* Staff Exh. 62; Stamatakos Rebuttal Post Tr. 12648, at 4.

[43] To be sure, the Staff did not state that a future NPP would be approved at the PFS site with a MAPE of 2×10^{-4} (5,000-year return period). *See* Staff PF 6.97. Rather, this represents the mean MAPE for existing NPPs in the Western United States, and is information that would likely be considered in the event a new NPP is proposed to be sited in the WUS. Tr. 12760-61.

Intermountain west." State PF ¶ 455; emphasis added.[44] In this regard, it should be noted that the hazard curve slope (A_4/A_3) for the PFS site is approximately 2.25, as compared to the values presented by Dr. Arabasz, of 1.68 for Diablo Canyon, 1.92 for San Onofre, 1.81 for WNP-3, 2.72 for WNP-2, and 3.32 for Palo Verde. *See* State Exh. 203, at A-4; Stamatakos Rebuttal Post Tr. 12648, at 6. The PFS A_4/A_3 value of 2.25 fits within this envelope. Moreover, one can readily compute the average hazard curve slope (A_4/A_3) for the five NPPs in the WUS listed here, using the A_R values provided by Dr. Arabasz. The average A_4/A_3 value for these five NPPs (1.68, 1.92, 1.81, 2.72, and 3.32) is **2.29** -- which directly compares with the A_R value of **2.25** for the PFS site. Thus, the fact that the PFS site is not located near a tectonic plate boundary does not remove it from consideration as a WUS site for which a NPP MAPE of 2×10^{-4} (5,000-year return period) may apply.[45]

6.246. This is not to say that the seismic design a NPP in the Western United States must be approved if it corresponds to a seismic event with a MAPE of 2×10^{-4} (5,000-year return period). Thus, SECY-98-071 (Staff Exh. S) cites Reg. Guide 1.165, in stating that "a future [NPP] in the western United States can use as a safe shutdown earthquake the 10,000-year return period mean ground motion." *See* Staff Exh. S at 2. At the same time, as Drs. Cornell and Stamatakos stated,

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[44] The State claims that Dr. Cornell "noted the basis for the different risk reduction ratios for 'Western sites' is that the western sites are near tectonic boundaries, where the hazard curves are considerably steeper. Cornell Tstmy Post Tr. 7856, at 16-17, n.5." State's Findings at 191 n.67. This assertion mischaracterizes his testimony. In fact, Dr. Cornell stated that "higher risk reduction ratios . . . are achieved in western US sites near tectonic boundaries, where hazard curves are considerably steeper." Thus, Dr. Cornell cited the steeper hazard curves, rather than proximity to a tectonic plate boundary, as the basis for higher risk reduction ratios at WUS sites. This would apply as well to the PFS site, given its steep hazard curve, despite the fact that the site is not close to a tectonic plate boundary.

[45] The State later appears to agree, in part, stating: "Dr. Arabasz did not imply that 'only tectonic plate nuclear power plants may have a shorter return period than the 10,000 return period (MAPE=2×10^{-4})'" or that the slope of a site's hazard curve "is like a genetic marker that identifies . . . whether the site qualifies or not for a higher seismic hazard exceedance probability (lower MRP) under DOE-STD-1020." State's Findings at 195 (PF ¶ 461).

under Reg. Guide 1.165 a 5,000-year return period may be acceptable for a future NPP at a WUS site, if acceptable justification is provided. *See* Reg. Guide 1.165 (State Exh. 201), at 1.165-12; Tr. 8001-02, 12705, 12707. The State does not preclude this possibility. *See* State PF ¶ 451. Thus, contrary to the State's suggestion in State PF ¶ 457, the views expressed by the Staff in this proceeding are consistent with SECY-98-071 and Reg. Guide 1.165.

6.247. The State challenges Dr. Stamatakos' views concerning the significance of a hazard curve's slope, asserting that "[t]he key point overlooked by Dr. Stamatakos is that under DOE guidance, the steepness of the hazard curve at a site . . . determines whether one achieves a risk reduction ratio of 20 or more that can justify, in the case of DOE PC-4 facilities, a 5,000-year reference ground motion versus a 10,000-year ground motion. Tr. (Arabasz) at 10105-06, 10108." State PF ¶ 461. This statement misconstrues Dr. Stamatakos' testimony. Dr. Stamatakos did not take issue with the potential importance of a hazard curve's slope, but rather, challenged the State's belief that the steepness of a hazard curve slope depends upon whether a site is or is not located near a tectonic plate boundary. *See* Stamatakos Rebuttal Post Tr. 12648, at 4-5, 6-7; Tr. (Arabasz) 9137-39. As Dr. Stamatakos testified, even though the PFS site is not located near a tectonic plate boundary, the steepness of its seismic hazard curve (A_R = approximately 2.25) would render the PFS site comparable to high seismicity sites located near tectonic plate boundaries. *See* Stamatakos Rebuttal Post Tr. 12648, at 5-6; Tr. 12706. Dr. Stamatakos stated:

> [T]he steepness of the hazard curve is certainly important for engineering concerns but the factors that influence whether or not a hazard curve is steep or not go well beyond its geographical position. And that if the hazard curve meets the criteria for what is defined as tectonic plate sites which I in my testimony have argued that the PFS site does that it can meet the same kinds of criteria as those that were sighted (*sic*) [sited] near tectonic plate boundaries.

Tr. 12706. In sum, contrary to the State's characterization of Dr. Stamatakos' testimony (*see* State's Findings at 195-96 (PF ¶¶ 461-462), Dr. Stamatakos' testimony concerning the importance

of a seismic hazard curve's slope is not inconsistent with the views expressed by Dr. Cornell, which the State now appears to embrace.

6.248. While the State claims that Dr. Stamatakos' testimony in inconsistent with "evidence that the SSE reference probability for a hypothetical NPP at the PFS site is about 1 x 10^{-4} (10,000-year MRP)" (State PF ¶ 462), no such dichotomy exists. Dr. Stamatakos recognized the reference probability for NPPs of 1 x 10^{-4}, as well as the fact that existing NPPs in the Western United States have a mean MAPE of 2 x 10^{-4}. Thus, Dr. Stamatakos stated that the reference probability for NPPs is a MAPE of 1 x 10^{-4}, and that "analyses of nuclear power plants in the western United States . . . show that the estimated average mean annual probability of exceeding the safe shutdown earthquake for these NPPs is 2.0 x 10-4 -- which is equivalent to a 5,000-year return period earthquake." Stamatakos/Chen/McCann Post Tr. 8050, at 19. This testimony is entirely consistent with the Staff's Consolidated SER, which recognizes that the reference probability for NPPs in Reg. Guide 1.165 equates to "a mean annual probability of exceedance of 10-4," and further, that "analyses of nuclear power plants in the western United States show that the estimated average mean annual probability of exceeding the safe shutdown earthquake is 2.0 x 10^{-4} [citing DOE TR-003 (State Exh. 202)]." Staff Exh. C at 2-50. For these and other reasons, the Staff concluded that "the mean annual probability of exceedance for the PFS Facility may be defined as greater than 10-4 per year." *Id.* at 2-51. *See* Staff PF ¶ 6.77. Dr. Cornell similarly recognized these considerations. *See* Cornell Post Tr. 7856, at 847; Tr. 7886-89, 7996, 8002. Thus, the State's characterization of Dr. Stamatakos' testimony as inconsistent with other evidence is demonstrably incorrect.

6.249. Similarly, the State's description of the background leading to the Staff's issuance of its final SER (State PF ¶¶ 470-473), and its assertion that "parts of the rationale for the exemption have fallen by the wayside to be replaced by other justifications" (State PF ¶ 470) is

incorrect. The record shows that the Staff did not approve the PFS exemption request in its Preliminary SER of December 1999, but only cited the considerations which Geomatrix had listed in a document which PFS had submitted to the Staff. *See* Stamatakos Rebuttal Post Tr. 12648, at 1; Tr. 12679, 12685-86, 12691-92; Staff Exh. A at 2-44 - 2-45; *see also* Staff Exh. TT (Geomatrix, Feb. 1999), at 56; Tr. 10180-86 (Arabasz). Thus, while the State points to the bullets in the Staff's Preliminary SER (State PF ¶¶ 471-72), its focus is misplaced, in that the Preliminary SER reflects the Geomatrix discussion, and does not represent a Staff rationale for approving the PFS exemption request. Further, contrary to the State's assertion, the "bullets" listed in the Staff's final SER (Sept. 2000) when it approved the proposed exemption, have changed very little over time. *Compare* Staff Exh. NN (Final SER), at 2-42 - 2-43, *with* Staff Exh. PP (annotated copy of SSER No. 2, Dec. 2001), at 33-34, and Staff Exh. C (Consolidated SER) at 2-50 - 2-51; *see* Tr. 9857-60.[46]

6.250. The State challenges the Staff's view that the Geomatrix PSHA appears to be conservative (State PF ¶ 479). We note, however, that the State's witness, Dr. Arabasz, reached a similar conclusion based upon his review of that analysis, stating that the PFS seismic hazard curve produced in the Geomatrix PSHA, was developed "correctly and conservatively." Tr. 9973-75. Dr. Arabasz, who stated this opinion in an April 1999 report to the State, never retracted this statement, although he later claimed that he was referring to the methodology used by Geomatrix in characterizing seismic sources, rather than the PSHA results. *See* Tr. 9977-78, 10054-55. This claimed distinction is not readily apparent, however. The seismic hazard curve, developed by Geomatrix, provides a graphic presentation of the "results" of its analysis. Moreover,

[46] In State PF ¶ 473, the State also focuses on statements pertaining to "operational life" which appear in the modified rulemaking plan in SECY-01-0178 (Staff Exh. U), which were not advanced by the Staff in its rationale for approving the exemption request in this proceeding. It is not our role to assess any statements contained in the modified rulemaking plan, and such statements are irrelevant here where neither the Staff nor PFS rely upon such statements. *See* Staff PF ¶ 6.33 and n.94, in the Staff's Findings.

no evidence was presented by Dr. Arabasz or the State that any portion of the Geomatrix PSHA or the results of that analysis were not conservative.

6.251. The State asserts that the Staff's slip tendency analysis dose not support the Staff's view that the Geomatrix PSHA was conservative. State PF ¶¶ 481-483.[47] While the State points to "evidence of surface rupture of Late Quaternary deposits by the East fault," State's Findings at 206 (PF ¶ 483), it did not show that the Staff was unaware of such "evidence" -- and, indeed, the State concedes that Dr. Stamatakos explicitly recognized this factor. *Id.* at 205, *citing* Staff Exh. Q (Stamatakos Report) at 2-17.[48] Based on our review of the evidence, including the Staff's evaluation of the "evidence" referred to in the Geomatrix report, we do not share the State's view that the Staff's slip tendency analysis should be rejected on the grounds that it is based on "guesses" or "hypothetical, subjectively tuned modeling" (*Id.* at 206). Moreover, even if we were to accept the State's claims, they do not address or affect the Staff's conclusion, based on its 3D Stress slip tendency analysis, that the Geomatrix analysis is conservative insofar as it assumes that portions of the East fault near the site have the same tendency to slip as more distant portions of the East fault (whose orientation is more favorable to slip). See Staff Exh. C at 2-38 - 2-39; Stamatakos/ Chen/McCann Post Tr. 8050, at 13-16.

6.252. The State asserts that "[d]uring testimony Dr. Stamatakos admitted that the Geomatrix data indicate the slip rate on the Wasatch fault is "roughly a factor of three" – not ten – greater than the slip rate on the Stansbury fault. Tr. (Stamatakos) at 8235-36." State PF ¶ 486. This assertion is simply incorrect. In fact, in the testimony cited by the State, Dr. Stamatakos

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[47] The Staff has previously discussed this matter in Staff PF ¶¶ 6.65 - 6.70.

[48] The State cites the 1999 Geomatrix report at 48-49, referring to it as a reference in the Staff's Consolidated SER. *See* State PF ¶ 483. That portion of the Geomatrix report does not appear to be in evidence. *See* Staff Exh. TT. The record, however, shows that the Staff was fully aware of how Geomatrix analyzed and interpreted the East fault. *See, e.g.,* Staff Exh. Q at 2-17; Staff Exh. C at 2-32 - 2-33, 2-36 - 2-37, and 2-38 - 2-39.

recognized that the data in the Geomatrix report reflect a factor of three difference in slip rates between the Wasatch and Stansbury faults (1.1 mm vs. 0.4 mm) -- but he did not retract his stated view that other data (*i.e.*, the Martinez GPS data) show as much as a factor of ten difference in those slip rates,[49] as stated in the Staff's SER. Stamatakos/Chen/ McCann Post Tr. 8050, at 17; Staff Exh. C at 2-7; Tr. 8235-38 (Stamatakos), Tr. 9877 (Arabasz). *See* Staff PF ¶ 6.65 - 6.70 and n.114. However, even if the Wasatch slip rate is only three times greater than the Stansbury fault's slip rate, that is still a substantial difference -- which should result in a relatively greater earthquake hazard at Salt Lake City due to the Wasatch fault as compared to the hazard at the PFS site due to the Stansbury fault,[50] but which is not observed in a comparison of the seismic hazard curves for the PFS site and Salt Lake City. *See* Staff Exh. JJ, at 5; Stamatakos/Chen/McCann Post Tr. 8050, at 16-17; Staff PF ¶ 6.71. This supports the Staff's conclusion that the Geomatrix PSHA for the PFS site is conservative due to its treatment of slip rate, such that the only issue in dispute is the degree to which the Geomatrix analysis may be conservative due to its treatment of slip rate. *See* Tr. 9875-80; Staff PF ¶ 6.72 and n.114.

6.253. In State PF ¶ 487, the State asserts:

> The hazard calculation for Salt Lake City is based on the USGS National Earthquake Hazard Reduction Program (id. at 8109), whose hazard calculations would not be acceptable for the SAR at the PFS site. Id. at 8111. Although not explicitly acknowledged by Dr. Stamatakos, the reason for the latter is that the national hazard mapping is done on a regional scale and includes only major active faults. Id. at 8110.

State's Findings at 209. This statement mischaracterizes Dr. Stamatakos' testimony. In fact, Dr. Stamatakos stated only that it would not be acceptable to "use the National Earthquake Hazard

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[49] The Martinez data show a slip rate for the Wasatch fault of up to 5 mm/year. Tr. 8236.

[50] This is supported by the testimony of State witness Dr. Solomon, who stated that "the Wasatch fault zone, one of the longest and most active normal-slip faults in the world. . . . is 230 miles long, lies on the eastern edge of the Salt Lake City metropolitan area, and is capable of generating earthquakes as large as magnitude 7.5." Solomon Post Tr. 8965, at 3.

Reduction map to establish the design basis ground motions for the PFS site." Tr. 8111(emphasis added). Nowhere did Dr. Stamatakos state that the NEHRP's "hazard calculations" would not be acceptable.[51] Morever, the validity of Dr. Stamatakos' statement is readily apparent: If an applicant could simply reference an NEHRP map to establish its design basis, it would not have to conduct its own seismic analyses. That is not the basis upon which the NRC's regulations are constructed.

6.254. The State attempts to aggregate the slip rates for the Stansbury, East and East Cedar Mountain faults (0.4, 0.2, and 0.07mm/year, respectively), arriving at a "combined slip rate" of 0.67 mm/year -- which the State then compares to the Wasatch slip rate of 1.1 mm/year. State PF ¶ 487. This novel attempt to aggregate individual fault slip rate data was never addressed in the State's (or other parties') testimony, and we have been provided no reason to believe it is appropriate to do so. In this regard, we are mindful of Dr. Arabasz' admonition that "many a mickle make a muckle." *See* Tr. 9878. Moreover, even if we were to adopt this proposed aggregation, the fact remains that a combined slip rate of 0.67 is almost a factor of two lower than the Wasatch fault's slip rate of 1.1 mm/year -- and, yet, the seismic hazard for the PFS site is still calculated in the Geomatrix PSHA to be larger than the seismic hazard for the Interstate-15 sites calculated in the Dames and Moore PSHA, despite the fact that Salt Lake City is closer to a larger and more active fault. *See* Staff Exh. JJ, at 5.[52]

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[51] We note, too, that one of the principal reasons stated by the U.S. Department of Energy for its recent issuance of DOE-STD-1020-2002, in which it adopted a 2,500-year return period for PC-3 facilities in lieu of the 2,000-year return stated in DOE-STD-1020-94, was its desire to be consistent with and to utilize the NEHRP maps. *See* Staff Exh. II, at iv. While the State seemingly would ask us to disregard the value of the NEHRP maps, we have been shown no reason to believe that they are inaccurate or that DOE's stated desire to utilize the NEHRP maps is flawed.

[52] The State also asserts that "[w]ithout independently performing site-specific PSHAs for the two sites, the Staff's inference that the Geomatrix PSHA is conservative by comparison to sites in or near Salt Lake City is only speculation." State PF ¶ 487. The State, however, fails to recognize that both the USGS seismic hazard curve for Salt Lake City and the Dames and Moore seismic hazard results for the I-15 project were computed using PSHA methodology. See Staff Exh. JJ, at 3-4. Both of those PSHA results portray a lower seismic hazard than the hazard shown

(continued...)

6.255. Further, while the State asserts that the results of two different PSHAs cannot be compared "without scrutinizing the respective methodologies used" (State PF ¶ 489), we find no reason why a valid comparison of the resulting seismic hazard curves cannot be made, at least for purposes of examining, even on a crude basis, whether one of those analyses produced seismic hazard curve results which are palpably greater than expected. Moreover, we note that each of the hazard curves in question (for PFS, Salt Lake City, and the I-15 sites) were prepared by established, professional organizations (Geomatrix, the U.S. Geological Survey, and Dames & Moore, respectively), and each of their PSHAs were available for review by the parties. *See* Staff Exh. JJ, at 3-5.[53] Thus, we do not share the State's misgivings about the usefulness of Dr. Stamatakos' comparison of the seismic hazard curves produced by these three PSHA studies.

6.256. The State claims that Dr. Arabasz "agreed to the adequacy of Geomatrix's PSHA (Tr. at (Arabasz) 9119) but would not agree that its hazard results were conservative (*e.g.*, id. at 9861-63, 9878-79, 10128-31)." State PF ¶ 490. The State's assertion is not supported by the testimony cited by the State herein. Moreover, it is clear that Dr. Arabasz conceded that the PFS seismic source characterization was developed "correctly and conservatively," and we have been shown no reason to believe that other portions of the Geomatrix PSHA, or its results, were not conservative as well. *See* Staff PF ¶ 6.250, *supra,* and testimony cited therein.

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[52](...continued)
by Geomatrix for the PFS site. *Id.* at 5.

[53] The State asserts that the Salt Lake City and San Francisco Bay Bridge results shown in Staff Exh. JJ appear to be comparable for low ground motions (State PF ¶ 489). The basis for this assertion is unclear, in that the plots shown in Staff Exh. JJ show differences between those seismic hazard curves at low ground motions. In any event, however, the State's assertion simply makes the Staff's point -- *i.e*., the plots show that the PFS site and Salt Lake City "challeng[e] San Francisco's hazard" (State's Findings at 211), which suggests that the Geomatrix PSHA results for the PFS site may be overly conservative as compared to the seismic hazard curves developed for Salt Lake City and San Francisco.

6.257. The State contests Dr. Stamatakos' view that either the Geomatrix PSHA is conservative, or the site has high seismicity, which would justify a higher reference probability (lower return period). State PF ¶ 491. According to the State, this is a "false dilemma." *Id.* We see no such dilemma. As noted above, the slope of the PFS site seismic hazard curve developed by Geomatrix (A_R = 2.25) is steep; and Geomatrix' PFS seismic hazard curve predicts ground motions larger than those for Salt Lake City (2 studies) and rivals those in California. *See* Staff Exh. JJ, at 5. Dr. Arabasz agrees that the reference probability for a NPP at the PFS site would be greater than 1×10^{-4} (i.e., return period less than 10,000-years); he estimated that the reference probability for a NPP, based on analyses of existing SSEs and following the methodology in Regulatory Guide 1.165, would equate to a return period of about 8,000-9,000 years. Tr. 10113-14.[54] Dr. Cornell similarly stated that the reference probability for a future NPP in the WUS may be somewhat higher than for a NPP in the CEUS. Tr. 8001-02. We need not determine, here, what standard should be set for any future NPP applicant at the PFS site. We only note that the evidence supports a conclusion that the reference probability for a future NPP at the PFS site would likely be greater than 1×10^{-4} (*i.e.*, return period less than 10,000 years).

6.258. The State contrasts the areas of expertise possessed by Drs. Arabasz and Stamatakos, and urges that greater weight be accorded to Dr. Arabasz' views given his "familiarity and experience with earthquake conditions in Utah, seismology and seismic hazard analysis," and

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[54] By comparison, a recent study of earthquake hazard annual exceedance probabilities, discussed in DOE-1020-2002, shows that using probabilistic hazard methodologies, the safe shutdown earthquake (SSE) level for 69 NPPS in the Eastern United States ("EUS") generally corresponds to an annual frequency of exceedance of between 0.1×10^{-4} (100,000-year return period) and 10×10^{-4} (1,000-year return period). Staff Exh. QQ, at C-14 and Fig. C-4. For 2/3 of those plants, the SSE design spectra correspond to probabilities between about 0.4×10^{-4} (25,000-year return period) and 2.5×10^{-4} (4,000-year return period). *Id.* at C-14. As Dr. Arabasz observed, a median of the means for the 69 NPPs in the EUS is about 1.1×10^{-4} (9,500-year return period). Tr. 10251-52. The Staff's testimony similarly indicates that the MAPE for these 69 NPPs in the Eastern U.S. is "slightly greater than 1×10^{-4}." Stamatakos/Chen/McCann Post Tr. 8050, at 28. As a shorthand, this is referred to as a MAPE of approximately 1×10^{-4}. Tr. 10254 (Arabasz); Staff Exh. QQ, at C-14.

Dr. Stamatakos' allegedly "lesser degree of experience with the broad scope of PSHA issues here. State PF ¶ 492. We are mindful of Dr. Arabasz' expertise in the areas addressed in his testimony and, as we have stated, we appreciate his appearance and testimony before us. Tr. 10225 (Farrar, J.). This does not, however, detract from the qualifications and expertise of Staff witness Dr. Stamatakos, who demonstrated an in-depth knowledge of geophysics, tectonics, seismic and faulting hazards, and PSHA matters -- and who was joined in his testimony by Dr. Martin McCann (Tr. 8045, 8048-49), an internationally recognized leader in PSHA methodology and seismic risk assessment. *See* McCann Qualifications, Post Tr. 8050, at 1-4. Moreover, we recall the benefit provided early in the evidentiary hearings from the PSHA tutorial lesson that was provided at our request jointly by Drs. Stamatakos and McCann. *See* Tr. 5812-45. Thus, we are fully satisfied as to Dr. Stamatakos' qualifications and expertise to address the matters discussed in his testimony, and as to the reliability of his testimony.

6.259. The State contrasts the Staff's approach in assessing the PFS exemption request to the approach followed in DOE-1020-2002, asserting that the Staff's approach has not evolved to the level of sophistication and rigor required by DOE. State PF ¶ 505. The State urges that we adopt the DOE approach as our own: It would have us require that "the DBE must be formally linked to a specific performance goal and risk reduction ratio." State PF 506. Further, the State urges us to find that the Staff has not established a performance goal (failure probability) for this facility or any previous ISFSIs, and that the Staff "has not coupled a performance goal and risk reduction ratio to the 2,000-year DBE for the PFS facility." *Id.* The State, however, fails to observe that Dr. McCann, whose testimony it cites in support of these statements (*Id., citing* Tr. 8140 and Tr. 8143), actually stated that the Commission (rather than the Staff) has not taken these steps.[55]

[55] With respect to the Staff's approach in this proceeding, Dr. McCann explained that the seismic hazard analysis and a determination as to the appropriate probability of exceedance were linked to the probability of exceedance, in that NRC standards with inherent levels of conservatism (continued...)

While the State urges us to impose the DOE standard as a regulatory requirement here, we have no regulatory basis to do so in that the NRC is not obliged to follow DOE's approach -- as the Staff recognized in deciding not to impose the DOE approach as a requirement here. Stamatakos/Chen/McCann Post Tr. 8050, at 21, 30. However, like DOE, the Staff included considerations of risk upon determining to approve a MAPE of 5 x 10^{-4} (2,000-year return period) as the design basis ground motion for the facility, *Id.* at 30, although this involved a qualitative, rather than quantitative, assessment. Tr. 8137-38.[56] Thus, in granting the exemption request, the Staff relied on the Commission's insights, wherein the Commission concluded that the risk posed by an ISFSI are

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[55](...continued)
were applied, and the design was reviewed to assure that the design standards were satisfied:

> It would be incorrect to say that our review of the seismic hazard analysis and our ultimate conclusion as to the exemption request and what is an appropriate probability of exceedance of the design-basis ground motion is totally uncoupled to the performance of the facility. . . .
>
> The application. . . is being submitted to the Nuclear Regulatory Commission. What is established are the engineering standards to which the facility would be designed. . . . In recognizing that NRC standards, engineering standards were going to be imposed upon the design process, there are, therefore, levels of conservatism, seismic margin, if you will, that will be brought to bear in the design, and therefore it was recognized that that was a given. It wasn't something we had to address explicitly, but it was fully recognized as to what that meant. . . .
>
> [T]he design would be submitted to the Commission for their review, and the other side of the house, if you will, would review and presumably judge as to whether or not the standards have been satisfied.

Tr. 8142-44. Further, he explained that the Staff had the benefit of DOE's thinking, recognizing that DOE had gone through a similar evolutionary process. Tr. 8137-38.

[56] As stated in the Staff's Findings, the Commission has previously observed that an ISFSI poses significantly less radiological risk than a NPP; and the Commission's consideration of this fact was specifically addressed in the Staff's evaluation of the PFS exemption request and in the testimony of the Staff's witnesses. *See* Staff PF ¶¶ 6.76, 6.92, 6.98, and 6.101.

inherently and substantially less than the risk posed by a NPP. Nowhere in these proceedings did the State challenge the merits of this determination by the Commission.

6.260. With respect to the probability of failure, the State alleges that Mr. Guttmann's testimony serves as a basis for finding "that the issue in the cask stability analysis is whether the Applicant has reasonably demonstrated that the HI-STORM 100 cask will not tip over when subject to the design basis earthquake." As discussed above, cask tipover analyses may well focus on whether a cask will tipover; this is not, however, the issue before us; nor did Mr. Guttmann establish this as the issue to be decided here. Rather, the issue before us is established by regulation -- *i.e.*, (a) whether, pursuant to 10 C.F.R. § 72.122(b)(1), PFS structures, systems, and components important to safety ("SSCs") are designed to accommodate the effects of, and be compatible with, site characteristics and environmental conditions and to withstand postulated accidents, and (b) whether, pursuant to § 72.122(b)(2), the SSCs are designed to withstand the effects of natural phenomena, including earthquakes, without impairing their capability to perform safety functions. As stated elsewhere in this decision, we are satisfied that the PFS design meets these requirements.

6.261. At various points in its proposed findings, the State asserts that "no party" or "no other party" disagrees with various statements contained therein. *See, e.g.*, State PF ¶¶ 504, 509, 531. In doing so, the State cites testimony by the State, or by the State and Applicant, but fails to provide any citation to Staff testimony which would support that assertion. We cannot give any consideration to such assertions as what may be the (unstated) position of another party. For example, in State PF ¶ 531, the State contests Dr. Cornell's testimony that "'typical' NPP SSCs have a risk reduction factor in the range of 5 to 20 or greater," and that "the acceptance criteria, procedures, and guidelines in the NRC Standard Review Plans ('SRP') for NPPs have risk reduction ratios 'as large as, or larger than' those established for PC4 facilities in DOE Standard

1020." State's Findings at 226 (*citing* Cornell , Post Tr. 7856 at 19-20). According to the State, "[n]o other party supports the Applicant's 'similarity argument.'" *Id.*[57] However, contrary to the State's assertion, the Staff's testimony clearly draws a parallel between the reference probability for NPPs of 1×10^{-4} stated in NRC Regulatory Guide 1.165, and DOE's use of the same value as the seismic design standard for DOE PC-4 facilities, which are similar to commercial NPPs. *See* Stamatakos/ Chen/McCann Post Tr. 8050, at 20-21, 28. While the Staff did not attempt to quantify the risk reduction ratio inherent in NRC regulatory guidance, it draws the same conclusion as DOE -- *i.e.*, that considering the lower radiological risk posed by an ISFSI as compared to a NPP, an ISFSI licensed by the NRC may utilize a design basis comparable to the design basis set for PC-3 facilities under the DOE paradigm. *Id.* at 30-32. Thus, we cannot find, as the State asserts, that "no other party" supports the Applicant's "similarity" argument.

6.262. The State asserts that "the methods used to analyze the sliding and tipping stability of free standing casks are not normally encountered in NPP SSC analyses," State PF 532 *citing* Tr. 7970 (Cornell), and therefore, "risk reduction ratios encompassed in SRPs for reactor pressure vessel and primary coolant systems at nuclear power plants cannot be inferred under PFS's 'similarity argument' to free standing dry storage casks." *Id.*, *citing* Tr. 7969 (Cornell). However, the testimony cited by the State does not support its claims. Dr. Cornell stated only that NPP SSCs do not typically include freestanding casks or an assessment of the likelihood of tipover -- but the NPP analyses use the same "ASME stress and allowable criteria when evaluating the effects of tipover accidents, etc." Tr. 7970. Thus, we cannot find that the methods and criteria utilized in NPP safety analyses are different from those used in ISFSI safety analyses, except insofar as the NPP analyses do not include an assessment of the likelihood of cask tipover.

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[57] The State begins this discussion by imputing to Dr. Cornell a statement that "the risk reduction ratio for ISFSIs is 'similar' to that calculated for 'typical SSCs' commonly found at NPPs" State PF ¶ 531. We have been unable to find that statement in his testimony.

6.263. In State PF ¶ 534, the State would have us find that "DOE-STD-1020 has greater risk reduction factors than does NUREG/CR-6728. State's Findings at 227. We need not reach this finding. As discussed *supra*, at ¶ 6.238, NUREG/CR 6738 represents the work of an NRC contractor which has not been adopted or approved by the agency as yet. Moreover, that document is not in evidence, and was not cited among the bases for this contention. Accordingly, while we have been shown no reason to disagree with any statements contained therein, we have no reason to evaluate it at this time or to determine whether this document or DOE-STD-1020-2002 provides greater risk reduction factors.

6.264. The State asserts that "Dr. Cornell's opinion that SCCs [sic] at the PFS facility have risk reduction ratios of '5 to 20 or greater' is inconsistent with his other testimony that the margins are 2 to 3 times the design basis capacity." State PF ¶ 537, *citing* Tr. 7916-17 (Cornell). However, the testimony cited by the State does not support its conclusion. In the statement cited here, in response to a question by Judge Lam, Dr. Cornell compared the factor of 2 or 3 margin that exists between a facility's "design basis capacity" and its "actual capacity," under either the deterministic approach in 10 C.F.R. Part 100, Appendix A or a probabilistic approach with a 2,000-year return period. The cited testimony does not concern the establishment of a risk reduction ratio, nor is there any evidence in the record as to the relationship between these two types of values. We therefore cannot find that this testimony by Dr. Cornell undermines his testimony concerning risk reduction ratios.

6.265. Consistent with its urging that we adopt the DOE-STD-1020 paradigm, the State urges us to find that "the Applicant has not met its burden of demonstrating that its SCCs [sic] meet a supportable performance goal and risk reduction factors for a 2,000-year DBE" (State PF ¶ 538); that "neither PFS nor any party credibly established appropriate performance goals and risk reduction factors for the PFS facility" (State PF ¶ 539); and that "absent a regulatory framework

which establishes performance goals and risk reduction ratios, . . . conservatism in the PFS seismic design for a 2,000-year DBE cannot be measured" (State PF ¶ 540). State's Findings at 229. We cannot make these requested findings. As stated above, the Commission has not adopted the DOE paradigm. We therefore cannot find that an application that fails to follow that approach must be rejected in an NRC licensing proceeding, or that an NRC Staff review that does not follow that DOE approach is inadequate. Rather, applying NRC regulatory standards, we must determine whether the seismic design of a facility provides adequate protection of public health and safety. As stated elsewhere in this decision, we are satisfied that the PFS seismic design, including its use of the seismic design basis of 5×10^{-4} established in the Geomatrix PSHA for the site, meets this standard.

6.266. Finally, in State PF ¶ 542, the State urges us to find that "PFS has not shown that there is adequate conservatism to demonstrate appropriate risk reduction factors"; that "the Staff has not presented testimony on this issue"; and that "there is insufficient reliable or probative evidence in the record to find that a 2,000-year DBE at the PFS site is reasonably conservative." State's Findings at 230. In fact, however, the Applicant's testimony provides a quantification of the conservatisms present in its seismic design. Further, the Staff's testimony provides a further demonstration that the PFS design is "reasonably conservative," based on both (a) quantitative analysis (*e.g.*, Dr. Stamatakos' assessment of conservatisms in the Geomatrix PSHA seismic hazard curves, and Mr. Water's radiological dose analysis), and (b) qualitative considerations (e.g., the Staff's consideration of the relative radiological risks posed by a NPP and an ISFSI). We therefore find no basis to render the finding proposed by the State.

6.267. For the reasons stated herein and in the Staff's Findings of September 5, 2002, we find that a seismic ground motion with a MAPE of 5×10^{-4} (2,000-year return period) constitutes an acceptable design basis earthquake for the proposed PFS Facility, and that the occurrence of a

design basis earthquake with a MAPE of 5 x 10^{-4} at the PFS site will not result in adverse consequences to public health and safety. We now turn to radiological dose considerations.

2. Radiological Dose Considerations.

6.268. The State urges us to consider whether PFS has shown that "unanchored HI-STORM 100 casks would 'reasonably maintain confinement of radioactive material' under off-normal and credible accident conditions at the PFS site, as required by 10 C.F.R. § 72.236[.]"[58] State's Proposed Findings at 230. As set forth in 10 C.F.R. § 72.13(c), however, § 72.236 applies to activities associated with a certificate of compliance. Section 72.236, by its own terms, applies to a "certificate holder and applicant for a CoC," and not to an applicant for a site-specific license. Rather, the general design criteria applicable to confinement barriers and systems for site-specific ISFSIs are set forth in 10 C.F.R. § 72.122(h), which is one section specified as applicable to activities associated with a specific license in 10 C.F.R. § 72.13(b). Moreover, the State acknowledged at the hearing that the beyond-design-basis accident issue before us does not relate to a loss of confinement. Specifically, the State's counsel stated as follows:

> I think one of the issues here is how does one go about determining the appropriate length of the accident. And the Staff moved into evidence a NUREG document that had a suggested rule of thumb for a confinement accident, *which this is not*, so that this is reference to a government guide by analogy.

Tr. 12610 (statement of Ms. Curran) (emphasis added). We have examined Unified Contention Utah L/QQ, Part E, Subpart 2, and it does not refer to a loss of confinement. To the extent the State is now asserting that a design basis earthquake might cause a loss of confinement, we believe that such an issue is not within the scope of the contention, as admitted. It is neither fair nor consistent with our usual practice to allow a last-second infusion of new elements into a

[58] The State mistakenly cites this requirement as being in 10 C.F.R. § 72.236(b) (State PF at 231). It appears in 10 C.F.R. § 72.236(l).

previously admitted contention. *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-20, 56 NRC ___, slip op. at 2 (Oct. 1, 2002).[59]

6.269. The State also argues that "by allowing PFS to use the [section] 72.106(b) standard, the Board would be expanding the effect of PFS's request to be exempted from 10 CFR § 72.102 to a dilution of the standard in 10 CFR § 72.106(b)." State PF at 234-35 (¶ 554). As explained above in ¶ 1.23, this is incorrect. The issue in this portion of the contention is whether the proposed PFS facility would satisfy the Commission's dose consequence requirements in the event of a correctly specified design basis earthquake. For the reasons set forth below, we have determined that PFS has satisfied those requirements.

6.270. With respect to the State's dose calculations, Dr. Resnikoff used an occupancy time at the site boundary of 8,760 hours in calculating dose in the event of a cask tipover accident, and the State asserts that the Staff agreed with this length of time for estimating dose. State PF at 236 and n. 78 (¶ 559). While the Staff requested that Holtec International use an 8,760 hour exposure time in calculating annual doses under § 72.104(a) in connection with the CoC, this is simply irrelevant to the PFS site-specific accident dose calculations under consideration here. *See* Staff PF at 235, n.128.

6.271. Specifically, the documentation the State identifies as showing that the Staff "agreed" with Dr. Resnikoff as to the use of 8,760 hours for estimating dose is the rule in which the NRC approved the CoC for the HI-STORM 100 cask system. State PF at 236 (¶ 599), citing 65 Fed. Reg. 25241, 25245 (2000). In the rule, however, the NRC approved the HI-STORM 100 cask system for use by general licensees under 10 C.F.R. Part 72, Subpart K; since PFS does not

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[59] While State witness Resnikoff included assertions regarding the effects of forces on the MPC in his testimony (Resnikoff, Post. Tr. at 8), he readily admitted under cross-examination that he had no expertise in analyzing such effects. Staff PF at 233, n.126; 237-38 (¶¶ 6.150-6.152). Furthermore, the only probative evidence on the matter adduced at hearing was that cask tipover would not result in a loss of confinement. Tr. 12076 (Testimony of Dr. Singh); *see* Staff PF at 251-52 (¶¶ 6.188-6.190); Staff Exh. C at 9-6, 11-8 to 11-9, 15-9, and 15-122.

hold a license under 10 C.F.R. Part 50 and is not a general licensee under Subpart K, the rule did not approve use of the cask system at the proposed PFSF. *See* 65 Fed. Reg. at 25241. In addition, Part 72 provides separate regulations for cask certification and site-specific license applications. *See* 10 C.F.R. § 72.13. Indeed, the Staff reviews requests for such licensing actions using different standard review plans, namely, NUREG-1536 (for cask certification reviews) and NUREG-1567 (for facility licensing reviews). Staff Exh. 53 and 58; *see also* PFS Exh. 239. Therefore, the State's assertions with respect to exposure time used in connection with the CoC are irrelevant to the site-specific accident dose consequence analysis. *See also* Staff's Findings of September 5, 2002, at n.128.

6.272. The State implies that its dose calculations are underestimates in that Dr. Resnikoff testified that "there are other dose contributors that he did not consider."[60] State PF at 233 (¶ 550). Dr. Resnikoff started with the dose rate at the bottom of a HI-TRAC transfer cask. State Exh. 141 at 1.[61] As documented in the Consolidated SER, the Staff evaluated the dose rate calculated for the HI-TRAC transfer cask, and accepted the Applicant's and the cask vendor's use of certain computer codes in modeling the shielding configurations and materials to be used at the proposed PFSF. Staff Exh. C at 7-5. We are not aware of any assertion that the calculation for the HI-TRAC transfer cask is somehow incomplete, or left out any dose contributors. Based on the Staff's SER, it appears to us that Dr. Resnikoff's calculations were founded upon a dose rate that did, in fact, include all relevant dose contributors.

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[60] The State cites transcript pages 12371 and 12380 for this proposition. In response to the Applicant's question about the doses included in his own calculations, however, Dr. Resnikoff stated that "I'm not agreeing that those are the only dose contributors" (Tr. 12371). In addition, in reiterating that point in response to another Applicant question, he stated that "[there] may be other contributors." Tr. 12380 (emphasis added). These statements are a far cry from the positive assertion that there are, in fact, additional dose contributors.

[61] State Exhibit 141A superseded State Exhibit 141 only where the errors in the calculation are corrected in the tables. Tr. 12355 (response of Ms. Curran to Applicant's question).

6.273. Furthermore, Dr. Resnikoff did not identify any nuclide considered in the HI-TRAC dose rate analysis that was later removed from his evaluation.[62] In addition, the State failed to present evidence to quantify the dose contributors asserted to be left out of Dr. Resnikoff's calculations.[63] Had the State believed such asserted dose contributors important to this issue, it should have presented evidence on their nature and extent. In view of the foregoing, the State's assertion that some dose contributors were omitted does not raise any reasonable uncertainty with respect to the dose calculations in the record.

6.274. The State also asserts that "a calculation should be performed using the Monte Carlo method, especially with respect to the bottom of tipped over casks." State PF at 233 (¶ 551). Again, if the State believed such a calculation so important, it should have included one in the evidence it submitted. Nonetheless, we are satisfied that the evidence of record is sufficient for us to reach a conclusion on the issue of dose consequences.

6.275. With regard to the duration of an event, the State refers to the "situation" at the Palisades reactor, which has "lingered on for more than five years without resolution." State PF at 239 (¶ 566). On cross-examination by the Staff, Dr. Resnikoff admitted that if there was no radiation hazard because of cracking in an MPC, then there would be no reason why such a condition would have to be rectified promptly -- and that, in fact, the shielding of the cask at Palisades remained intact. Tr. 12635-36. Accordingly, we find that the circumstances at Palisades are not relevant to our determination here.

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[62] To be sure, Dr. Resnikoff modeled the fuel gamma doses as originating with Cs-137. State Exh. 141 at 1. This modeling assumption is apparently based on Cs-137's being a primary gamma contributor among fission products in spent nuclear fuel. Tr. 12638. The assumption does not indicate that gammas from fission products other than Cs-137 were somehow ignored.

[63] Dr. Resnikoff did state that he had omitted from his calculations the dose resulting from gammas produced by the interaction of neutrons with shielding material. Tr. 12356-60; 12493. Dr. Resnikoff testified that this dose was included in Dr. Redmond's Monte-Carlo calculations. Tr. 12359-60. Including neutron and gamma doses, Dr. Resnikoff estimated a total dose of 150 mrem/yr at the site boundary. Tr. 12356-60; *see* State Exh. 141A.

6.276. The State suggests that we find that "PFS has not calculated the amount of time before a cask must be uprighted in order to avoid a loss of integrity of concrete shielding." State PF at 244 (¶ 583). State witness Resnikoff, however, admitted that he lacks the expertise necessary to address structural integrity issues. *See* Staff PF at 233, n.126. With respect to potential evaporation of the hydrogen, the evidence indicates that any resulting loss of shielding would be minimal, at most. *Id*. at 233, n.126; 238 (¶ 6.153); 242 (¶ 6.164); 255-56 (¶¶ 6.200-6.204); Singh/Soler/Redmond, Post Tr. 12044, at 27-28. Accordingly, we find no need to require PFS to calculate the amount of time that would be required to upright the casks.

6.277. The State claims that "PFS acknowledged that it has no way of excluding anyone from the northern part of the controlled area boundary because it does not own the property," and that "it is difficult to predict what conditions will be in 20 years – or 40 years when PFS expects its license will terminate." State PF at 235 (¶ 557). The State appears to be implying that, based on potential changes in land use, the dose consequences resulting from a cask tipover event should be calculated considering the presence of an individual at the site boundary 24 hours per day for the duration of the event. As set forth below, the Staff's analysis assumes a 24-hour presence at the OCA boundary for 30 days. *See* ¶¶ 6.278-6.281, *infra*; Staff's Findings of September 5, 2002, at 257 (Staff PF ¶ 6.205). No further assumption of 24-hour occupancy or potential changes in land use is warranted.

6.278. The State indicates that the Staff's witness, Mr. Waters, performed his calculations assuming that an individual was at the site boundary 24 hours per day. State PF at 235 (¶ 556). Specifically, the State refers to testimony it elicited from Mr. Waters on cross-examination that it is reasonable to assume that necessary action would be taken to remove people at the site boundary within 30 days. *Id*. at 237 (¶ 561), *citing* Tr. 12267. Mr. Waters, however, also clearly indicated in response to the State's questions that he considered that temporary shielding could

be appropriately placed around the storage casks within 30 days to reduce direct doses, if direct dose were a consideration or problem. Tr. 12268-69. Mr. Waters explained that he used a residence time at the site boundary of 30 days, for 24 hours per day (*i.e*, 720 hours), in calculating the accident dose in the event of cask tipover. Tr. 12265-68; Waters, Post Tr. 12215, at 13. In response to questions posed by the Licensing Board, Mr. Waters also explained that although the regulation does not specify 30 days, "we have to assume some exposure time to ensure that the regulation is met." Tr. 12312.

6.279. The State also claims that Mr. Waters' testimony that "30 days was reasonable" is not based on evidence of the "existence of any contingency plan or actual knowledge of how long it would take to restore the site to pre-accident conditions." State PF at 237 (¶ 561).[64] By this statement, the State implies that Mr. Waters believed the site could be restored to pre-accident conditions within thirty days. This is incorrect. Mr. Waters did not state that the accident would terminate in 30 days but, rather, explained that doses could be reduced by taking mitigative measures within 30 days. *See* Tr. 12266-69. Further, he specifically stated as follows:

> MS. CHANCELLOR: And specific to the PFS site, did you assume that casks could be uprighted in 30 days?
>
> MR. WATERS: No, I did not.

Tr. 12266. The State's implication that Mr. Waters' testimony was based on restoring the site to pre-accident conditions, or that prompt restoration is necessary, is incorrect.

6.280. With regard to recovery from a beyond-design-basis accident, the State suggests that we rely on Dr. Resnikoff's statement that it is unlikely that all the casks could be uprighted in

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[64] Similarly, the State contends that PFS did not explain how installing steel plates around fallen casks would actually terminate the accident when the casks have not been uprighted. *Id*. at 239 (¶ 565).

a short period of time. *Id*. at 238 (¶ 563).[65] Similarly, the State emphasizes its assertions that there is no contingency plan in the event of a cask tipover accident. *Id*. at 238 (¶ 563), 239 (¶ 565),[66] 240 (¶ 567), 241 (¶ 570). Continuing in this vein, the State urges us to find that there is "no rational basis to presume that after a serious accident, PFS would be able to restore the site to normal conditions in only 30 days." *Id*. at 240 (¶ 568). The State also urges us to conclude that if contingency measures are to be relied on in a licensing decision, they must be planned, and not ad hoc. *Id*. at 241 (¶ 572).

6.281. The State misapprehends the nature of the Staff's responses to the State's questions. Rather than considering a cask tipover accident as a design basis accident, the Staff stated that such an accident is beyond the design basis. Tr. 12269 (Waters). The Staff did not describe what actions would be necessary to restore the site to normal conditions in the event of such a beyond-design-basis accident. Rather, the Staff, in responding to the State's questions on cross-examination, merely explained how general principles of radiation protection might be applied in the event of such an accident. Tr. 12266-67 (Waters). Such principles are consistent with the NRC guidance in NUREG-1567. *See* Staff PF at 266-67 (¶ 6.235) and n.137. Based upon these considerations, the Staff derived a 30-day exposure time for calculating doses from a beyond-design-basis hypothetical cask tipover event. Tr. 12266-67. As also indicated in the Staff's responses to the State's questions, there is no requirement for a contingency plan for a beyond-

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[65] The State cites Dr. Resnikoff's testimony at Tr. 12506 in support of the proposition that "it is unlikely that all the casks could be uprighted in a short period of time." State PF at 238 (¶ 563). There is no such statement at Tr. 12506. Similarly, the State claims that Dr. Resnikoff testified that "if casks are impinging on each other, it would be difficult to pick a single cask up" (citing Tr. 12507), and "it could be difficult to find a place to set a cask down" citing Tr. 12507-08. While Dr. Resnikoff may well have testified as described, that testimony is not documented at Tr. 12507-08. These transcript pages do not support these assertions.

[66] The State cites Dr. Redmond's testimony at Tr. 12126 in response to the Board's questions, stating that "once again PFS did not have any contingency plan." State PF at 239 (¶ 565). In its questions at Tr. 12126, however, the Board did not inquire as to any PFS contingency plans, and Dr. Redmond was silent on that matter.

design-basis accident. Tr. 12269 (Waters). In view of the foregoing, there is no need for us to make a finding with respect to the time necessary for the site to be returned to normal conditions following a beyond-design basis accident or with respect to the need for contingency plans for such an event.

6.282. The State indicates that Mr. Waters assumed that 50 casks would be tipped over facing a northern direction, and that he considered that this would be the bounding case. State PF at 243 (¶ 577). Mr. Waters, however, considered the tipover of all 4,000 casks, with either the tops, bottoms, or sides facing in the northern direction. Waters, Post Tr. 12215, at 16-17; Tr. 12257. Mr. Waters also explained that casks not on the outer periphery of the storage pads would not significantly contribute to the resulting offsite dose rate. Waters, Post Tr. 12215, at 17. Rather, they would be shielded because the casks would be lined up with each other. Tr. 12257.

6.283. The State urges us to find it reasonable to require PFS to either prepare a defensible model of the configuration of tipped-over casks, or to make conservative assumptions about their configurations. State PF at 243 (¶ 579). The State further urges us to find that in the absence of such a model or assumptions, we cannot find the reasonable assurance of safety that the regulations require. *Id*. To make such findings, however, would require us to ignore the Staff's conclusion that the Applicant's analysis demonstrated that the casks will not tip over in the event of a design-basis seismic event. *See* Staff PF at 251 (¶ 6.187). We would also have to ignore the Staff's testimony that cask tipover would not result from a 10,000-year return period earthquake at the proposed PFS Facility. *Id*. at 252 (¶ 6.191). Further, we would have to ignore that portion of the Staff's testimony in this proceeding in which the Staff considered three different cask alignments that might result from cask tipover (namely, all cask tops directed towards the site boundary; all cask bottoms directed towards the site boundary; and all cask sides directed towards the site boundary). *Id*. at 260 (¶¶ 6.216-6.217); Waters, Post Tr. 12215, at 16-17. The State

provides no discussion of the Staff's testimony in this regard, and we will not ignore that testimony. Accordingly, we reject the State's suggestion.

6.284. For the reasons stated herein and in the Staff's Findings of September 5, 2002, we find that the dose consequence limits of 10 C.F.R. § 72.106(b) will not be exceeded in the event of (1) a design-basis earthquake with a 2,000-year return period at the PFS site, (2) an earthquake with a 10,000 year return period at the site, or (3) a hypothetical, beyond-design-basis, multiple cask tipover event at the proposed PFS facility.

Respectfully submitted,

/RA/

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Dated at Rockville, Maryland
this 16th day of October, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Independent Spent Fuel Storage Installation)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF'S REPLY FINDINGS OF FACT AND CONCLUSIONS OF LAW CONCERNING UNIFIED CONTENTION UTAH L/QQ (GEOTECHNICAL ISSUES),'" in the above captioned proceeding have been served on the following through deposit in the NRC's internal mail system, with copies by electronic mail, as indicated by an asterisk, or by deposit in the U.S. Postal Service, as indicated by double asterisk, with copies by electronic mail this 16th day of October, 2002:

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