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DOCKETED
USNRC

October 23, 2002 (4:12PM)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

DOCKET NUMBER
PROPOSED RULE PR 72
(67FR47745)

October 22, 2002

Ms. Annette L. Vietti-Cook
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Att'n: Rulemakings and Adjudications Staff

Re: **Comments on Proposed Rule to Amend 10 C.F.R. Part 72: Geological and Seismological Characteristics for Siting and Design of Dry Storage Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations**

Dear Ms. Vietti-Cook:

Pursuant to the Nuclear Regulatory Commission's ("NRC") Notice of Proposed Rulemaking (67 Fed. Reg. 47745) (July 22, 2002) ("NRC Notice"), we are pleased to submit the following comments on behalf of Private Fuel Storage, L.L.C. ("PFS"). The proposed rule would amend the requirements of 10 C.F.R. Part 72 to add a new provision, 10 C.F.R. § 72.103, to the regulations for determining the geological and seismological characteristics for dry cask modes of spent fuel storage and other forms of radioactive waste. This new section would provide that the Design Earthquake Ground Motion ("DE") for dry cask modes of storage located west of the Rocky Mountain Front are to be evaluated using methods, such as a probabilistic seismic hazard analysis ("PSHA"), that appropriately address inherent uncertainties in determining an appropriate DE. Proposed 10 C.F.R. § 72.103(b).[1]

The NRC Notice specifically requests comments on the "appropriate mean annual probability of exceedance value to be used for the seismic design of an ISFSI or MRS and what is the justification for this probability." 67 Fed. Reg. at 47752. In this respect, the Notice advises that the Commission is "considering allowing the use of a mean annual probability of exceedance for the DE in the range of 5×10^{-4}," which equates to a DE with a mean return interval of 2,000 years. Id.

[1] The new section also establishes standards for dry cask sites east of the Rocky Mountain Front. Proposed 10 C.F.R. § 72.103(a). These comments are focused only on proposed 10 C.F.R. § 72.103(b).

Template = SECY-067

SECY-02

PFS is in a unique position to provide informed comments on the proposed rule. Over the past several years, PFS has been involved in extensive litigation in the 10 C.F.R. Part 72 licensing proceeding for the Private Fuel Storage Facility ("PFSF") (Docket No. 72-22) over its request for an exemption to use a 2,000-year mean return period DE for the PFSF. In that proceeding, PFS presented testimony from one of the world's leading experts on risk-informed seismic design, Dr. C. Allin Cornell,[2] concerning the advantages of using PSHA methods for determining the DE as well as the appropriateness of using a 2,000-year mean return period DE for a dry cask storage facility such as the PFSF. With Dr. Cornell's assistance, PFS demonstrated that the conservatisms inherent in designing a dry cask storage facility to a 2,000-year DE following the NRC's Standard Review Plan design criteria and procedures would enable such a facility to withstand earthquakes of much greater magnitude than a 2,000-year return period event without the release of radioactive materials. PFS also responded to arguments made by parties opposing the use of a 2,000-year DE for the PFSF, and was able to show that those arguments were contrary to well-established concepts of risk-informed seismic design.

PFS's comments summarize the evidentiary record developed on this issue in the proceeding for the licensing of the PFSF. As part of these comments, PFS is submitting the relevant pre-filed testimony of some of its witnesses[3] as well as the relevant portions of its Proposed Findings Fact and Proposed Reply Findings of Fact[4] submitted in the PFSF licensing

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[2] Dr. Cornell is a highly regarded expert in the areas of probabilistic earthquake and seismic structural engineering. He published the seminal paper on characterizing earthquake hazards using PSHA methods and has been actively engaged throughout his career in the development of seismic codes and standards. He was one of the originators of seismic probabilistic risk analysis ("PRA") studies for nuclear power plants and has participated in numerous seismic PRA studies for nuclear facilities. He is a recognized expert in risk-informed seismic design and in evaluating the conservatisms that exist in seismic codes and standards. Cornell Dir. at A2-A7; <u>see also</u> PFS F. ¶¶ 414, 423, 428.

[3] Testimony of C. Allin Cornell ("Cornell Dir.") (April 1, 2002) attached as Tab 1; Rebuttal Testimony of C. Allin Cornell to the Testimony of State witness Dr. Walter Arabasz on Section E of Unified Contention Utah L/QQ ("Cornell Reb.") (June 27, 2002) attached as Tab 2; Testimony of Krishna P. Singh, Alan I. Soler, and Everett L. Redmond, II on Radiological Dose Consequence Aspects of Basis 2 of Section E of Unified Contention Utah L/QQ ("Singh/Soler/Redmond Dir.") (April 1, 2002) attached as Tab 3. (Handwritten changes reflect changes made at time the testimony was admitted and incorporated into the record.)

[4] Applicant's Proposed Findings of Fact and Conclusions of Law on Unified Consolidated Contention Utah L/QQ (Seismic) ("PFS F.") (Sept. 5, 2002), attached as Tab 4; Applicant's Reply to the Proposed Findings of Fact and Conclusions of Law of the State of Utah and the NRC Staff on Unified

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proceeding. These materials set forth in detail the reasons why the use of a 2,000-year DE based on PSHA methods is appropriate for dry cask storage facilities, such as the PFSF.[5]

PFS's comments consist of three parts. In the first part, PFS addresses the appropriateness of using PSHA methods for the seismic design of dry cask storage facilities, such as the PFSF. In the second part, PFS responds to the NRC's request for comments on the appropriateness of using a 2,000-year mean return period DE for such facilities. In third part, PFS provides its response to comments that it anticipates will be filed by the State of Utah opposing the use of a 2,000-year mean return period DE for dry cask storage facilities.

A. Comments on Appropriateness of Using Probabilistic Seismic Hazard Analysis Methods for the Seismic Design of Dry Cask Storage Facilities

The NRC Notice identifies several advantages of using PSHA methods for determining the DE compared to the deterministic methods currently provided for by 10 C.F.R. Part 72.[6] In this respect it should be noted that the PSHA methodology is the prevalent methodology in use today for determining the design-basis ground motions for the seismic design of a wide range of structures and facilities. Cornell Dir. at A15. Dr. Cornell testified that the PSHA methodology has become widely accepted and used because of its many advantages. These include: (1) the probabilistic approach captures more fully the current scientific understanding of earthquake forecasting than the deterministic method; (2) the probabilistic approach is capable of reflecting the uncertainties in professional knowledge of key elements of the seismic hazard; and (3) the probabilistic approach can be used to set design criteria that are consistent among different

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Consolidated Contention Utah L/QQ (Seismic) ("PFS RF.") (Oct. 16, 2002), attached as Tab 5. (Handwritten changes reflect subsequent errata.)

[5] Both PFS's Findings and Reply Findings contain numerous references to the evidentiary record amassed in litigating this issue, which PFS is not attaching to these comments given that the PFSF record is readily available to the Commission (and the public) for use and consideration as appropriate in the current rulemaking.

[6] As reflected in the NRC Notice, the Commission in 1996 amended 10 C.F.R. Part 100 "to update" its nuclear power plant regulations to require the use of PSHA methods for the seismic design of new nuclear power plants in lieu of Appendix A to Part 100. 67 Fed. Reg. at 47746; 10 C.F.R. §100.23. As discussed in the NRC Notice, the rationale given for that change is equally applicable to the proposed changes to Part 72. 67 Fed. Reg. at 47746, 47749.

regions and among different failure consequences, thus allowing a rational and a equitable allocation of safety resources. Cornell Dir. at A16.

The widespread acceptance of PSHA methods is demonstrated by the fact that in the PFSF licensing proceeding, the experts for all the parties – including those for the State of Utah, who opposed the use of a 2,0000-year DE for the PFSF – agreed that the use of PSHA methods for determining the seismic design of the PFSF was preferable to the deterministic methods currently provided for by Part 72. PFS F. ¶¶ 403-09.

B. Comments on Appropriateness of Using a 2,000-Year Mean Return Period Earthquake for Seismic Design of Dry Cask Storage Facilities

PFS's comments in this section summarize generally accepted risk based principles, under which it can be determined that a 2,000-year return period DE is appropriate for dry cask storage facilities, and describe the application of these principles.

1. General Principles for Risk-Informed Seismic Design

In the PFSF proceeding, Dr. Cornell testified to two general principles of risk-informed seismic design, which again were generally accepted by all the parties to the proceeding.

The first general principle is that there should be a risk-graded approach to seismic safety that allows facilities and structures whose failure would have lesser adverse consequences to have larger mean annual probabilities of failure than those allowed for facilities for which the consequences of failure would be more severe. In other words, under a risk-graded approach to seismic safety, the less severe the anticipated consequences of failure, the larger the probability of failure that can be tolerated. Cornell Dir. at A20-A24. This fundamental principle of risk-informed seismic design was uniformly accepted by the experts for all the parties in the PFSF proceeding. PFS F. ¶ 414.[7]

The second general principle of risk-informed seismic design articulated by Dr. Cornell is that the adequacy of the DE to provide the desired level of seismic safety is judged based on two

[7] In the NRC Notice, the Commission recognizes the applicability of this principle by stating that the design peak seismic ground acceleration for dry cask storage facilities "need not be as high as for a NPP" because the seismically induced radiological risk associated with a dry cask storage facility is significantly less than the risk associated with a NPP. 67 Fed. Reg. at 47749.

considerations or factors: (1) the mean annual probability of exceedance ("MAPE") of the DE and (2) the level of conservatism incorporated into the criteria and procedures for the design of the facility. Cornell Dir. at A20. Underlying this second general principle is the fact that the design procedures and acceptance criteria for seismic design usually include conservatisms that are not explicitly identified and which reduce the risk of failure. Because of the conservatisms incorporated in seismic design procedures and acceptance criteria, the probability of failure of a seismically-designed facility is less than the MAPE of the governing DE, meaning that seismically-designed systems, structures and components are able to withstand a more severe, i.e., more infrequent, earthquake than that used as the DE. Cornell Dir. at A25-A26.

Therefore, in determining the appropriate DE to use under a risk-graded approach to seismic design, such as that adopted by the Commission, one must take into account the conservatisms embedded in the acceptance criteria and design procedures recommended in the Staff's Standard Review Plan for nuclear power plants ("NPPs") (NUREG-0800) ("NPP SRP") and other applicable Standard Review Plans ("SRPs").[8] Again, the widespread acceptance of this second principle of risk-informed seismic design is demonstrated by the fact that in the PFSF licensing proceeding the experts for all the parties accepted this principle. PFS ¶ 423.

2. Adequacy of a 2,000-year DE for Dry Cask Storage Facilities under Principles for Risk-Informed Seismic Design

a. Seismic Performance Standards

In the PFSF proceeding, PFS demonstrated that the conservatisms embedded in the design acceptance criteria set forth in the NRC's SRPs would enable a typical dry cask storage facility designed to a 2,000-year DE, such as the PFSF, to survive an earthquake with a mean return period of 10,000 years or more without releasing radioactivity to the environment. In other words, the probability of a release of radioactivity to the environment would be less than 1×10^{-4}. Cornell Dir. at A34-A55; PFS F. ¶¶ 424-53; PFS RF. ¶¶ 375-454.

A performance standard of less than 1×10^{-4} for the failure of dry cask storage facilities provides adequate protection of public health and safety consistent with the risk-graded probabilistic approach that the Commission has adopted. Cornell Dir. at A55. Such a

[8] As discussed below, the inherent conservatisms in the acceptance criteria and design procedures in the SRPs provide large margins of safety that reduce the risk from earthquakes by a factor of at least five or more.

performance standard would allow a higher level of seismic failure for dry cask storage facilities than that allowed for commercial NPPs, which is appropriate under a risk-graded approach since the risks to public health and safety resulting from the failure of a dry cask storage facility are "significantly lower" than those resulting from the failure of a NPP. 67 Fed. Reg. at 47749. Further, a probability of seismic failure of 1×10^{-4} is consistent with the performance standard that the Department of Energy ("DOE") has adopted for dry cask storage facilities under its DOE-1020 standard. Cornell Dir. at A55. Finally, a performance standard of 1×10^{-4} provides a significantly lower probability of failure – i.e., a greater level of seismic safety – than seismic performance standards associated with critical public structures, such as interstate highway bridges and hospitals. Cornell Dir. at A92. Thus, as was agreed by the experts in the PFSF proceeding, a seismic probability of failure of 1×10^{-4} is an appropriate performance standard for dry cask storage facilities. PFS F. ¶¶ 426-427.

b. Risk Reduction Achieved By NRC Design Conservatisms

It is well established that the NRC NPP SRP design acceptance criteria and procedures contain many conservatisms that significantly reduce the probability of seismic failure for typical nuclear power plant components. These conservatisms are introduced through prescribed analysis methods, specification of material strengths, limits on inelastic behavior, etc. The existence of such conservatisms has been established by numerous seismic probabilistic risk analyses ("PRAs") and seismic margin studies performed for virtually every NPP in the United States. Cornell Reb. at A3. Dr. Cornell demonstrated that the conservatisms embodied in the NRC's NPP SRP reduced the risk of seismic failure for typical NPP components by a factor of at least 5 to 20 or more. Cornell Dir. at A31 and Att A.[9] In other words, a typical component designed to a DE of 2,000 years would have a probability of failure from 1×10^{-4} (corresponding to reduction in risk of 5) to 2.5×10^{-5} (corresponding to a reduction in risk of 20).

[9] For a range of hazard curve slopes, Dr. Cornell calculated a range of risk reduction factors for typical NPP SSCs of 8 to 32. Cornell Dir., Att. A at 3-4. Dr. Cornell adjusted the values to the slope of the hazard curve for the PFS site and arrived at ranges of 12-21 and 8-12 for different spectral accelerations. Cornell Dir., Att. A at 4. "For simplicity," he summarized his results as showing that "the [risk reduction factors] for typical SSCs designed to the NRC SRP are in the range of 5 to 20 or greater." Id. Thus, the lower bound risk reduction factor of 5 is quite conservative based on Dr. Cornell's calculation.

The SRPs for dry cask storage systems and facilities (NUREG-1536[10] and NUREG-1567[11]) generally provide for use of the same codes and standards as those employed for NPPs under NUREG-0800. Cornell Dir. at A34-A37. By virtue of this commonality of design procedures and acceptance criteria, similar risk reductions of 5 to 20 or more would apply to structures and components at dry cask storage facilities that are analogous either to typical NPP structures (e.g., concrete reinforced buildings) or to typical NPP components (e.g., cranes). Cornell Dir. at A39-A40. Risk reductions of at least 5 to 20 or more would also apply to foundations, since these have also been subject to the NPP seismic PRAs and margin studies and have not been found to constitute critical failure modes. PFS RF. ¶¶ 407, 438.

Given the decades of NRCs concern about seismic safety, one would expect *a priori* similar levels of conservatism in any structure, system, or component important to safety ("SSC") designed to the NRC's SRPs and hence a similar reduction in risk for a SSC – such as a free-standing storage cask – not typical of commercial NPPs. Cornell Dir. at A33. That such risk reduction factors are also applicable to free-standing casks was demonstrated in the PFSF proceeding. Cornell Reb. at A3; PFS F. ¶ 448. First, it was demonstrated that free-standing casks would not tip over even under 10,000-year beyond design basis ground motions. This was established both by PFS[12] and by independent studies performed by Sandia Laboratories on behalf of the NRC.[13] Such a demonstration establishes in and of itself the achievement of a performance standard of 1×10^{-4}.

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[10] U.S. Nuclear Regulatory Commission, NUREG-1536, *Standard Review Plan for Dry Cask Storage Facilities,* January 1997).

[11] U.S. Nuclear Regulatory Commission, NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities,* March 2000).

[12] PFS RF. ¶¶ 246-249; see also Testimony of Krishna P. Singh and Alan I Soler on Unified Contention Utah L/QQ at A112-A121 following Tr. 5750; PFS Exh 86C "PFSF Beyond Design Basis Scoping Analysis," Holtec Report No. HI-2022854; PFS. Exh. 86D (providing input and numerical results for PFS Exh. 86C); PFS Exh. OO (Visual Simulations of VisualNastran Cask Stability Analyses)

[13] See NRC Staff Testimony of Vincent K. Luk and Jack Guttmann Concerning Unified Contention Utah L/QQ (Geotechnical Issues), attached at Tab 6. As described in this testimony, Sandia prepared an comprehensive report for the NRC Staff entitled, "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage (PFS) Facility," Rev. 1, dated March 31, 2002. This report was admitted as Staff Exh. P in the PFSF licensing proceeding. In addition, Sandia has performed two additional site specific cask stability analyses for the NRC Staff. See PFS RF. ¶¶ 331-332.

Second, assuming a cask were to tip over in a seismic event no release of radioactivity would occur. The NRC requires that a license applicant for a dry cask storage facility perform a hypothetical cask tip-over analysis and drop analysis to demonstrate that even in the event of a cask tip-over the design basis limits for the dry cask system will be maintained. Because of the inherent margins involved in the design limits, much greater decelerations would be required before a breach of the radioactive confinement boundary would occur.

For example, the HI-STORM-100 Cask System manufactured by Holtec Inc. to be used at the PFSF has a design basis deceleration limit of 45g, but could withstand much higher levels of deceleration without breaching the stainless steel multipurpose canister in which the spent fuel is sealed. Although a deceleration of 45 g would be reached in dropping a cask in which the canister is protected a distance of approximately one foot, Holtec has shown by analysis that dropping an unprotected canister 45 feet onto a hard concrete surface would only result in the stainless steel canister reaching 41% of its failure limit. This demonstrates the huge margins against the release of radioactivity embodied in the design of typical dry cask storage systems, which protect against release of radioactivity to the environment even if a severe earthquake event were to cause a cask to tip over. Singh/Soler/Redmond Dir. at A40, A59-A60; PFS F. ¶¶ 534-37; PFS RF ¶¶ 308-314.[14]

The large margins against the release of radioactivity assure that typical dry cask storage systems can withstand earthquakes with a mean return period of 10,000-years, which provides adequate public safety in accordance with the risk-graded probabilistic approach that the Commission has adopted. Cornell Dir. at A55. Accordingly, a 2,000-year DE for dry casks storage systems provides adequate protection of the public health and safety.

3. Responses to Anticipated Comments by Others

PFS expects that the State of Utah, and perhaps other parties, will file comments making arguments similar to those pressed by the State in the PFSF licensing proceeding, contending that the use of a 2,000-year DE for dry cask storage systems is insufficient to protect public health and safety. We address some of these anticipated comments here.

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[14] The NRC Notice notes in this respect that even "if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity." 67 Fed. Reg. at 47749.

a. Other Public Standards Employ a DE of 2,500 Years.

It has been argued that the DE for a dry cask storage facility must have a return period of at least 2,500 years because certain interstate highway bridges, buildings designed under the International Building Code ("IBC"), and PC-3 facilities designed under DOE-STD-1020-2002 all use a DE of 2,500-years. However, a simplistic argument that focuses solely on the numerical DE ignores the general principles of risk-informed seismic design, discussed above, under which the determination of an appropriate DE must consider both the mean annual probability of exceedance of the DE and the level of conservatism incorporated in the acceptance criteria and procedures for the design of the facility. See PFS RF. ¶¶ 384-389.

Therefore, one cannot conclude that, just because other standards employ a higher DE, those standards provide a greater level of safety. Rather, one must evaluate the conservatisms embodied in the designs under the various standards. Such an evaluation shows that the level of safety for a dry cask storage facility designed to a 2,000-year DE following NRC mandated nuclear safety standards provides at least twice the level of safety attained by interstate highway bridges or buildings and facilities designed under the IBC to a higher DE of 2,500 years, but subject to less stringent design safety standards. Id; Cornell Dir. at A90-A93. [15]

b. Alleged Need to Have a Formalized Regime Like DOE-1020

It has also been argued that a risk-graded performance standard can not reasonably be implemented absent a regulatory framework, such as that in DOE-STD-1020, which formally establishes performance goals and risk reduction ratios. See PFS RF. ¶¶ 410, 449. However, such an argument ignores that numerous seismic PRAs and margin studies have measured the conservatism that is achieved under the NRC's regulatory framework. This conservatism has been further amply demonstrated by the cask stability evaluations performed both by Holtec and

[15] In 2002, DOE changed the DE for performance category 3 ("PC3") SSCs, which would include dry cask storage facilities, from a 2,000 to a 2,500-year return period earthquake. At the same time, however, DOE changed the risk reduction embodied in the design acceptance criteria and procedures for a PC3 facility from 5 to 4, such that the overall performance objective remained unchanged at 1×10^{-4}. Cornell Dir. at A28. Accordingly, this change by DOE is of no consequence in evaluating the acceptability of facilities applying a 2,000-year DE and designed to NRC design acceptance criteria and procedures. Such facilities similarly achieve at a minimum the same performance risk standard of 1×10^{-4}. See PFS RF ¶ 406.

Sandia for the PFSF, which show no cask tip-over for large, beyond-design basis earthquakes, and by Holtec' hypothetical cask tip-over analysis performed for the PFSF, which shows no breach of the radioactive confinement boundary even in the highly unlikely event a cask were to tip over. See discussion and citations supra.

c. Risk Reduction Factors Allegedly Don't Apply to Foundations

It has been argued that the risk reduction factors achieved by the conservatisms embedded in the NRC SRPs would not apply to foundations, such as the concrete pad on which dry casks would rest. However, the seismic PRAs and margin studies that have been performed for NPPs included potential foundation failure modes such as overturning, loss of bearing capacity, and sliding. Foundation failure modes did not show up in those studies as being critical failure conditions for the facilities. See PFS RF. ¶¶ 407, 438. Thus, the same if not larger risk reduction factors would apply to foundations. In this respect, evaluation of the actual safety margins of the foundations for the PFSF demonstrated that it was appropriate to apply the same risk reduction factors to the foundations that have been shown to be applicable for typical nuclear grade structures and components by the many NPP seismic PRAs and margin studies. See PFS F. ¶¶ 438-447; Cornell Dir. at A50-A51.

d. Alleged Uncertainties in Non-Linear Cask Stability Analyses and Alleged Need for Shake Table Testing to Validate Non-Linear Cask Stability Analyses

It has been strongly argued that the non-linear cask stability analyses by which it has been shown that dry storage casks will not tip over in an earthquake are inherently unreliable and highly sensitive to input parameters whose correct value can not be easily determined and thus, allegedly, the only way to demonstrate the validity of these results is to perform physical tests such as shake table testing. The premises on which this argument rests are wrong. Non-linear dynamic analyses are inherently reliable and, moreover, computer codes employing non-linear analysis are validated in accordance with NRC requirements to assure that they provide results that are anchored in reality. PFS RF. ¶¶ 214-216, 416. Additionally, proper input parameters for the cask stability analyses are not elusive unknowns but can be determined from basic physical principles, and the cask stability analyses have been shown not to be not highly sensitive to changes in input parameters. PFS RF. ¶¶ 250-300. Thus, shake table testing is unnecessary. PFS RF. ¶¶ 301-322.

Thus, these and numerous other arguments that have been raised to challenge the acceptability of using a 2,000-year DE for dry cask storage facilities are not rooted in scientific fact.

C. Conclusion

PFS appreciates this opportunity to provide the Commission comments on the Part 72 proposed rulemaking and to provide the Commission insights from the extensive record amassed on this issue in the PFSF licensing proceeding. As outlined above, the record developed in the licensing for the PFSF strongly supports the Commission's use of a-2,000 year DE for dry cask storage facilities west of the Rocky Mountain Front.

Respectfully submitted

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October 22, 2002

ATTACHMENTS TO PRIVATE FUEL STORAGE'S COMMENTS ON PROPOSED RULE TO AMEND 10 C.F.R. PART 72

TAB 1: Testimony of C. Allin Cornell

TAB 2: Rebuttal Testimony of C. Allin Cornell

TAB 3: Testimony of Krishna P. Singh, Alan I. Soler, and Everett L. Redmond, II

TAB 4: Applicant's Proposed Findings of Fact and Conclusions of Law on Unified Consolidated Contention Utah L/QQ (Seismic)

TAB 5: Applicant's Reply to the Proposed Findings of Fact and Conclusions of Law of the State of Utah and the NRC Staff on Unified Consolidated Contention Utah L/QQ (Seismic)

TAB 6: NRC Staff Testimony of Vincent K. Luk and Jack Guttman Concerning Unified Contention Utah L/QQ (Geotechnical)