



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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STAFF EVALUATION REPORT

INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. STN 50-528, STN 50-529, AND STN 50-530

1.0 INTRODUCTION

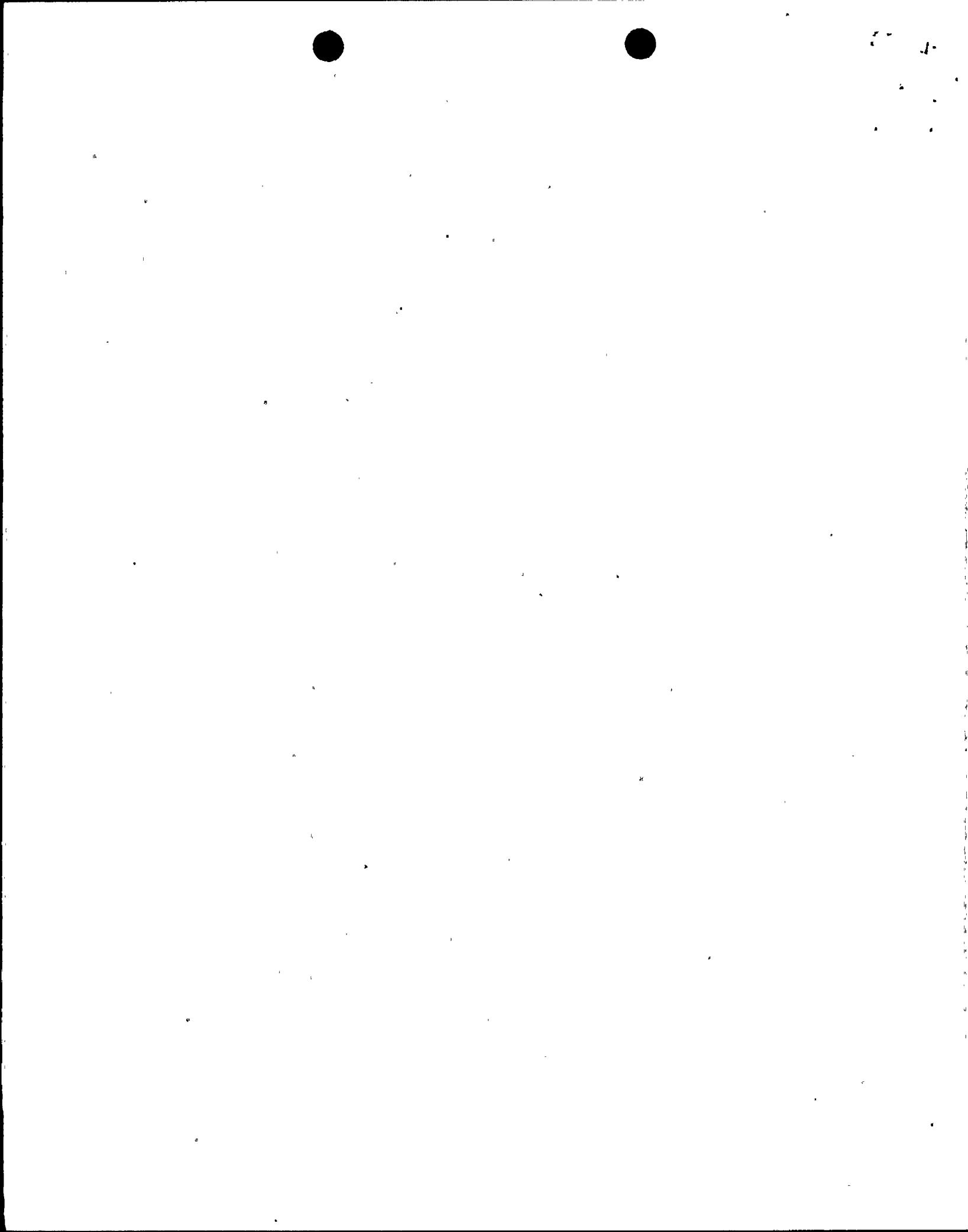
On June 28, 1991, the NRC issued Generic Letter (GL) 88-20, Supplement 4 (Ref. 1) along with NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examinations of External Events (IPEEE) for Severe Accident Vulnerabilities," requesting all licensees to perform an IPEEE to identify plant-specific vulnerabilities to severe accidents and to report the results to the Commission together with any licensee-determined improvements and corrective actions. In a letter dated June 30, 1995, the licensee, Arizona Public Service Company (APS or the licensee), submitted its response to the NRC (Ref. 2) for Palo Verde Nuclear Generating Station (Palo Verde), Units 1, 2, and 3.

The staff contracted with Brookhaven National Laboratory and Sandia National Laboratories to conduct screening reviews of the licensee's IPEEE submittal in the seismic and fire areas, respectively. The NRC staff conducted a screening review in the high winds, floods, and other external events (HFO) area of the submittal. The staff sent a request for additional information (RAI) to the licensee on October 23, 1997 (Ref. 3), and the licensee responded on February 27, 1998 (Ref. 4). Based on the results of the review of the submittal and the response to the RAI, the staff concluded that the aspects of seismic events, fires, and high winds, floods, and other external events were adequately addressed. The review findings are summarized in the evaluation section below. Details of the staff's and contractor's findings are presented in three technical evaluation reports (TERs) attached to this staff evaluation report.

In accordance with Supplement 4 to GL 88-20, the licensee provided information to address the resolution of Unresolved Safety Issue (USI) A-45, "Shutdown Decay Heat Removal Requirements," Generic Safety Issue (GSI)-103, "Design for Probable Maximum Precipitation (PMP)," GSI-57, "Effects of Fire Protection System Actuation on Safety-Related Equipment," and the Sandia Fire Risk Scoping Study (FRSS) issues. These issues were explicitly requested in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407. The licensee did not propose to resolve any additional USIs or GSIs as part of the Palo Verde IPEEE.

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An IPEEE Senior Review Board (SRB) was established and meets on a regular basis to review contractor performance. The purposes of the SRB are (1) for the contractor to present the findings and conclusions of its review and the bases for its conclusions, and (2) for the SRB members to provide their perspectives on the contractor's findings and conclusions and to make recommendations based on their technical expertise. In this manner, the SRB provides additional assurance that (1) the scope of the review meets the objectives of the program, and (2) critical issues that have the potential to mask vulnerabilities are not overlooked.

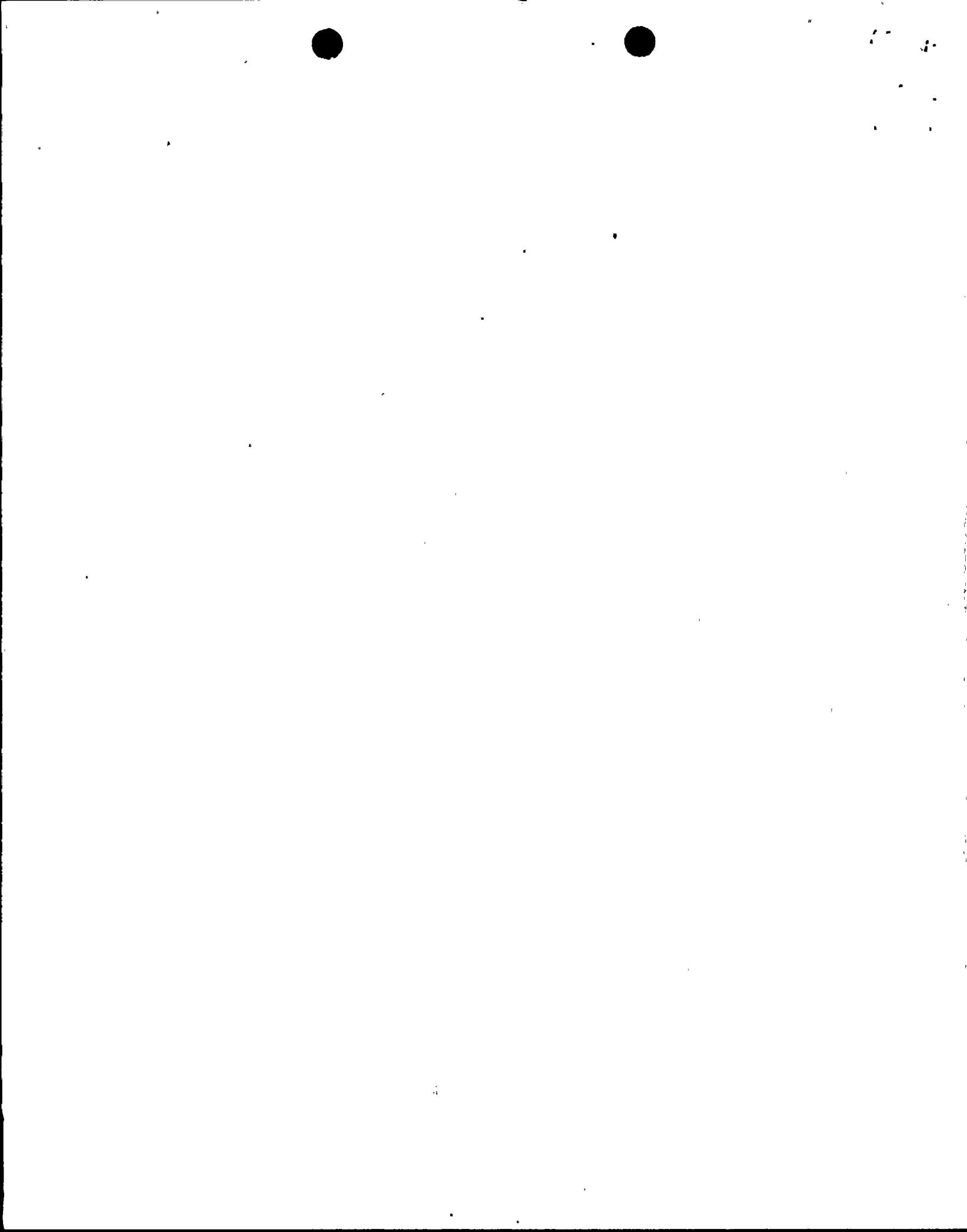
2.0 EVALUATION

Palo Verde is a Combustion Engineering System 80 pressurized-water reactor plant located approximately 34 miles west of the nearest boundary of the city of Phoenix, Arizona. The plant was designed to a seismic horizontal acceleration level of 0.13g operating basis earthquake. For the seismic analysis, the licensee conducted detailed plant walkdowns and used Electric Power Research Institute's (EPRI) seismic margin assessment (SMA) methodology (Ref. 5) in assessing the equipment capacity and the plant overall capacity for the review level earthquake (RLE) of 0.3g. In applying the SMA, the licensee developed two success path logic diagrams (SPLDs) and a safe shutdown equipment list (SSEL). High confidence of low probability of failure (HCLPF) values of critical equipment groups were also evaluated and judged for applicability to Palo Verde. For the fire analysis, the licensee used the fire-induced vulnerability evaluation (FIVE) methodology and performed plant walkdowns, fire area screening, and quantification of fire sequences due to fires in unscreened fire areas. For the analyses of other external events, the licensee used the progressive screening procedure as described in NUREG-1407.

2.1 Core Damage Frequency Estimates

Palo Verde was characterized in NUREG-1407 to be a 0.5g focused-scope plant. In April 1993, the licensee provided the staff a revised site-specific seismic hazard evaluation study to show that Palo Verde belonged to the 0.3g focused-scope group of plants. The staff approved this site hazard evaluation study and binning characterization on September 27, 1993. Thus, the licensee performed an EPRI-developed SMA of major plant equipment for the three units and screened the equipment based on EPRI screening criteria. Since the licensee used the SMA methodology rather than a seismic probabilistic risk assessment (PRA) (both methodologies are acceptable in accordance with NUREG-1407), no seismic core damage frequency (CDF) estimate was provided. HCLPF evaluations of major equipment groups were performed and judged for their reasonableness by the licensee. Based on the comparison of the RLE spectra and the design-basis in-floor response spectra, equipment anchorage verification, and resolution of spatial systems interactions, the licensee judged that HCLPF values of SSEL-related equipment at Palo Verde are higher than the RLE of 0.3g.

The total fire-induced CDF from unscreened fire areas was estimated to be about 8.7E-5 per reactor-year (RY). The licensee compared design and operational differences between Units 1, 2, and 3 and concluded that the Unit 1 fire CDF estimate was also applicable to Units 2 and 3.



The licensee estimated the CDF (referred to as frequency of loss of the ultimate heat sink) due to tornado missile loads to be about 1.9E-7, 4.0E-7, and 2.9E-9 per year for Units 1, 2, and 3, respectively. The CDFs due to other external events were not estimated since they were screened using the NUREG-1407 progressive screening approach.

The licensee estimated the CDFs due to internal events, including internal floods, to be about 9E-05 per RY for each of Units 1, 2, and 3.

2.2 Dominant Contributors

The licensee did not provide estimates of HCLPF values of SSEL-related equipment as part of the seismic evaluation. The licensee judged that the estimates of equipment HCLPF capacity and the containment HCLPF capacity are greater than the RLE of 0.3g. As part of this judgement, the licensee evaluated relay chatter for SSEL-related relays. The licensee also evaluated major walkdown findings for the SSEL-related equipment using an engineering verification assessment (Table 3-4 of the IPEEE submittal) and found that no seismic vulnerabilities existed at Palo Verde. Thus, no dominant contributors at the RLE level were believed to exist at Palo Verde.

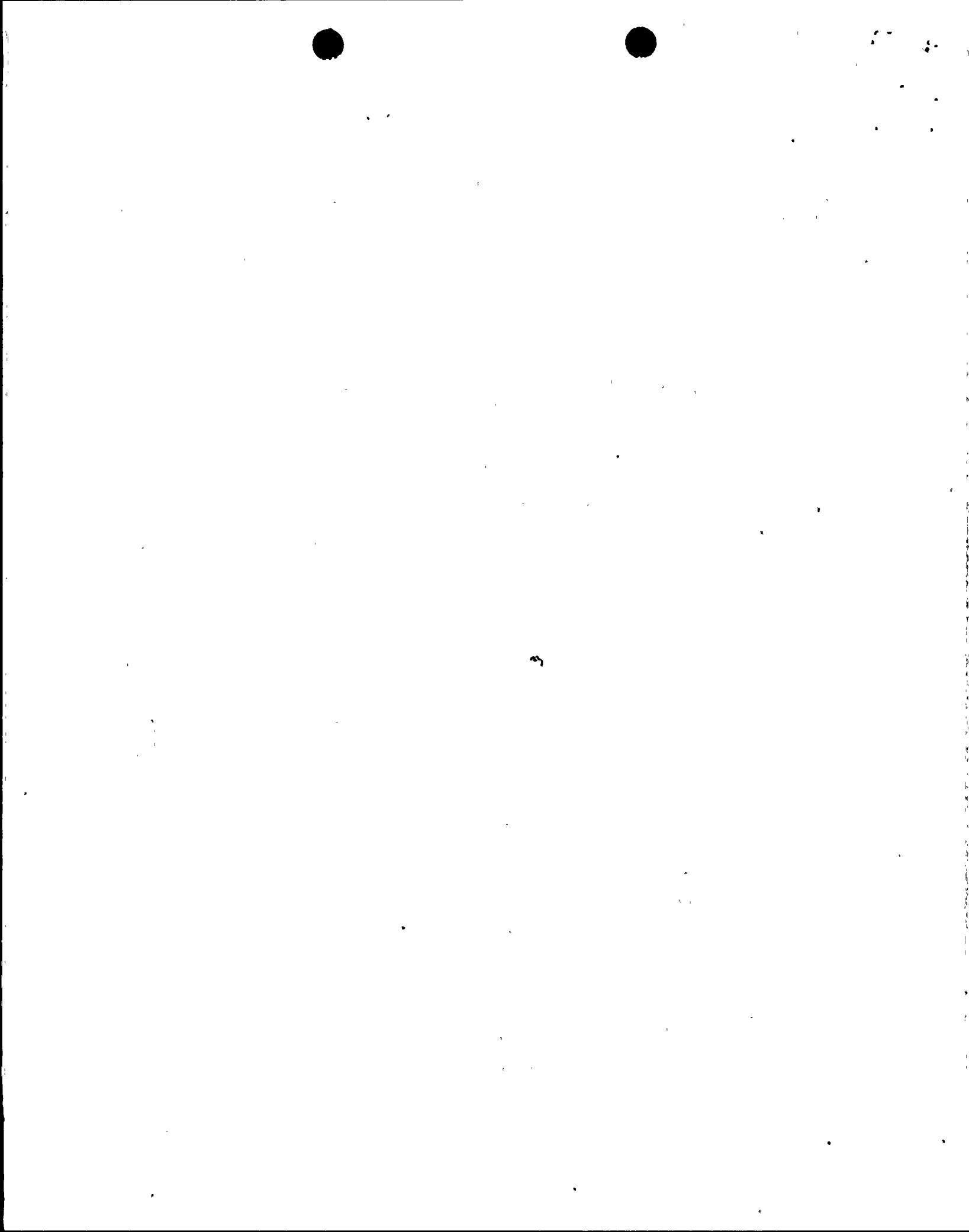
The licensee estimated the total fire-induced CDF to be about 8.7E-5 per RY. Train A engineered safety feature (ESF) switchgear fires were found to contribute significantly (24%) to the overall fire CDF. The dominant fire compartments that contributed to the total fire-induced CDF include the Train A switchgear room (2.1E-5 per RY), the turbine building lower levels west end (1.5E-5 per RY), the main control room (MCR) (1.1E-5 per RY), and the Train B switchgear room (9.7E-6 per RY). MCR fire scenarios include (1) fires that originate within control board B01, resulting in a loss of offsite power, (2) fires that originate elsewhere and spread to B01, again resulting in loss of offsite power, and (3) fires that originate elsewhere, but do not spread to B01 and do not result in loss of offsite power. All circuits related to offsite power and in-plant electrical distribution are located in control board B01. For fires affecting control board B01, Train A of safety-related systems was not assumed to be available in the control room, and Train B, whose control circuits can be disconnected from the control room prior to evacuation, was assumed to be available at the remote shutdown panel for safe shutdown operation by operators after they evacuate the MCR.

The total CDF due to HFO-related events was dominated by tornado missile loads.

The licensee's IPEEE assessment appears to have examined significant initiating events and dominant accident sequences for Palo Verde.

2.3 Containment Performance

The licensee evaluated critical containment failure modes, such as failure of containment isolation and performance of containment barriers, using the SSEL-related containment equipment list and the SMA evaluation approach and criteria. The containment walkdowns consisted of observing and evaluating unusual conditions or configurations (e.g., spatial interactions and unique penetrations). No unusual conditions or configurations were identified. Only one minor concern with the containment penetrations was observed and evaluated for further structural adequacy against the RLE of 0.3g. Failure of the containment structure was



screened based on the comparison of the design-basis in-floor response spectra and the RLE spectra for Palo Verde. Based on this evaluation, the licensee judged that the HCLPF value for the three Palo Verde containments is greater than the RLE of 0.3g.

The licensee evaluated the potential damage due to fires in the control building and the auxiliary building on containment isolation valve control circuits that could result in containment bypass. Fires in the containment class electrical penetration rooms were evaluated, and the evaluation indicated no impact on containment isolation failures. The containment spray system and the containment isolation system were also included in the evaluation of the failure of containment heat removal (CHR) due to internal fires. The licensee concluded that the mechanisms for containment failures due to loss of CHR are the same for internal fire scenarios as they are for other internal initiating events evaluated in the Palo Verde IPE. The IPPEEE internal fire analysis did not identify any additional containment failure modes that were not evaluated in the Palo Verde IPE.

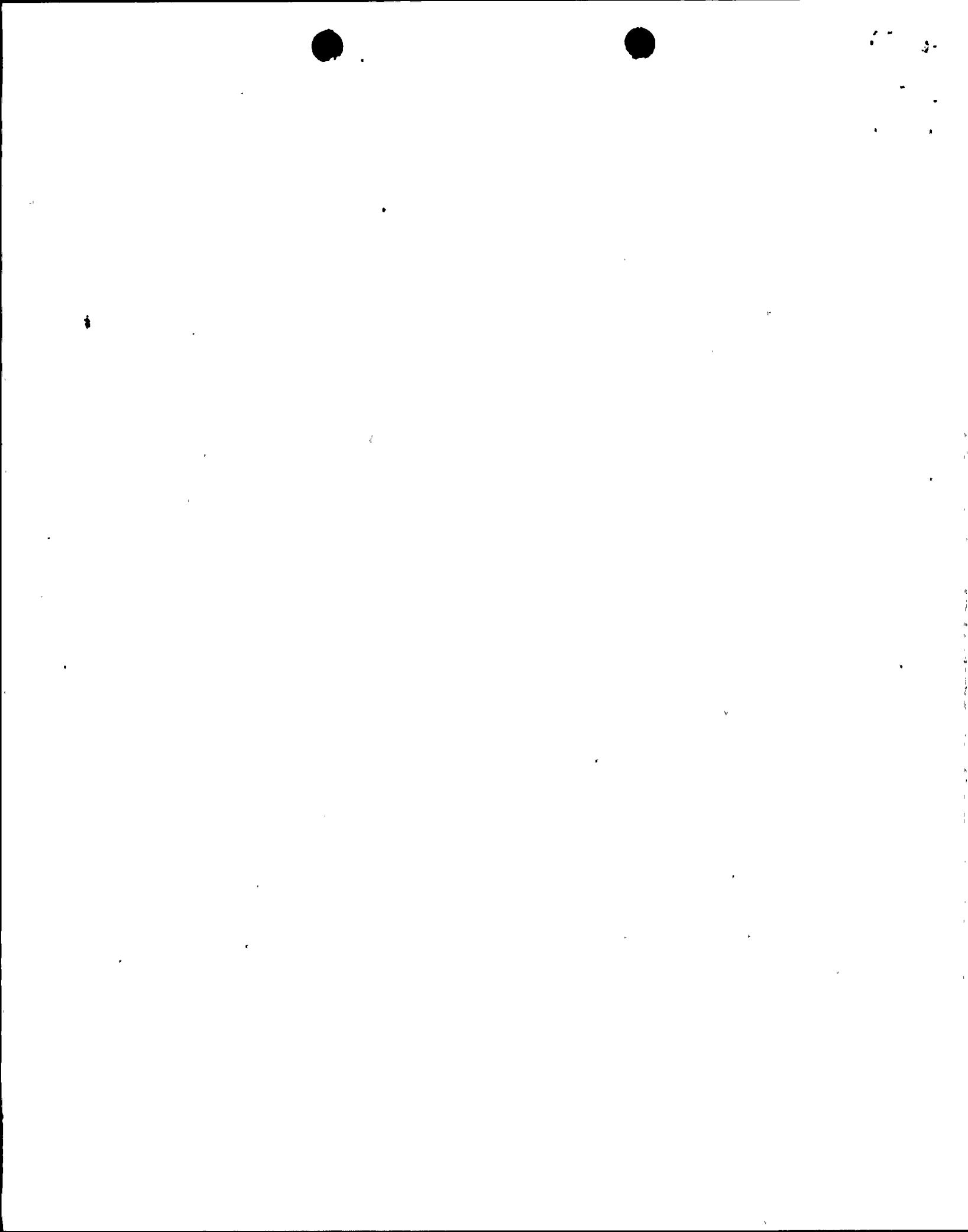
The licensee's containment performance evaluations for seismic and internal fires appears to have considered important containment performance issues and are consistent with the intent of Supplement 4 to GL 88-20.

2.4 Generic Safety Issues

As a part of the IPPEEE, a set of generic and unresolved safety issues (USI A-45, GSI-131, GSI-103, GSI-57, and the Fire Risk Scoping Study [FRSS] issues) were identified in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407 as needing to be addressed in the IPPEEE. These safety issues were evaluated by the NRC's contractors and the results of these evaluations are contained in the attached TERs. For those safety issues that were not completely resolved by the contractors, the NRC staff performed additional reviews in order to arrive at a satisfactorily conclusion. The final resolution of these issues is provided below.

2.4.1 USI A-45, "Shutdown Decay Heat Removal Requirements"

The licensee's evaluation of the seismic portion of the shutdown decay heat removal (DHR) is documented in Section 3.2 of the IPPEEE submittal. This evaluation included the development of plant-specific SPLDs and SSELs, Palo Verde-specific seismic margin assessment, including relay chatter evaluations, and plant walkdowns to identify seismically induced equipment failures and seismic II/I interactions. The IPPEEE also evaluated the impact of fire-induced faults of the DHR-related equipment (e.g., common cause failure of the air cooling system for the ESF switchgear rooms). The licensee's evaluation of the fire portion of the DHR is documented in Section 4.9 of the IPPEEE submittal. The licensee's evaluation of the HFO portion of the DHR is documented in Sections 5.1 and 5.3.2.3 of the IPPEEE submittal. The licensee made use of site-specific tornado missile impact calculations (Appendix 5.A), which were performed in demonstrating functional integrity of the essential spray ponds against tornado missile loads. The staff finds that the licensee's USI A-45 evaluation is consistent with the guidance provided in Section 6.3.3.1 of NUREG-1407, and, therefore, the staff considers this issue resolved for Palo Verde.



2.4.2 GSI-131, "Potential Seismic Interaction Involving the Movable In-Core Flux Mapping System Used in Westinghouse Plants"

Palo Verde is not a Westinghouse design. Therefore, GSI-131 is not applicable.

2.4.3 GSI-103, "Design for Probable Maximum Precipitation (PMP)"

The licensee evaluated the impact of the new weather data and the PMP criterion for high intensity rainfalls in short time intervals at the Palo Verde site. The IPPEE review indicates that the revised PMP data (e.g. the new hydro meteorological report (HMR) No. 49 published by the National Oceanic and Atmospheric Administration/Department of Commerce and associated calculations resulted in levels of roof ponding loads and site drainage flow discharge rates that were found to be bounded by the results of the original final safety analysis report (FSAR) calculations (Section 2.4.3.1 of the Palo Verde FSAR). Thus, the licensee concluded that the new PMP data was not a concern for Palo Verde. The staff finds that the licensee's GSI-103 evaluation is consistent with the guidance provided in Section 6.2.2.3 of NUREG-1407, and, therefore, the staff considers this issue resolved for Palo Verde.

2.4.4 GSI-57, "Effects of Fire Protection System Actuation on Safety-Related Equipment"

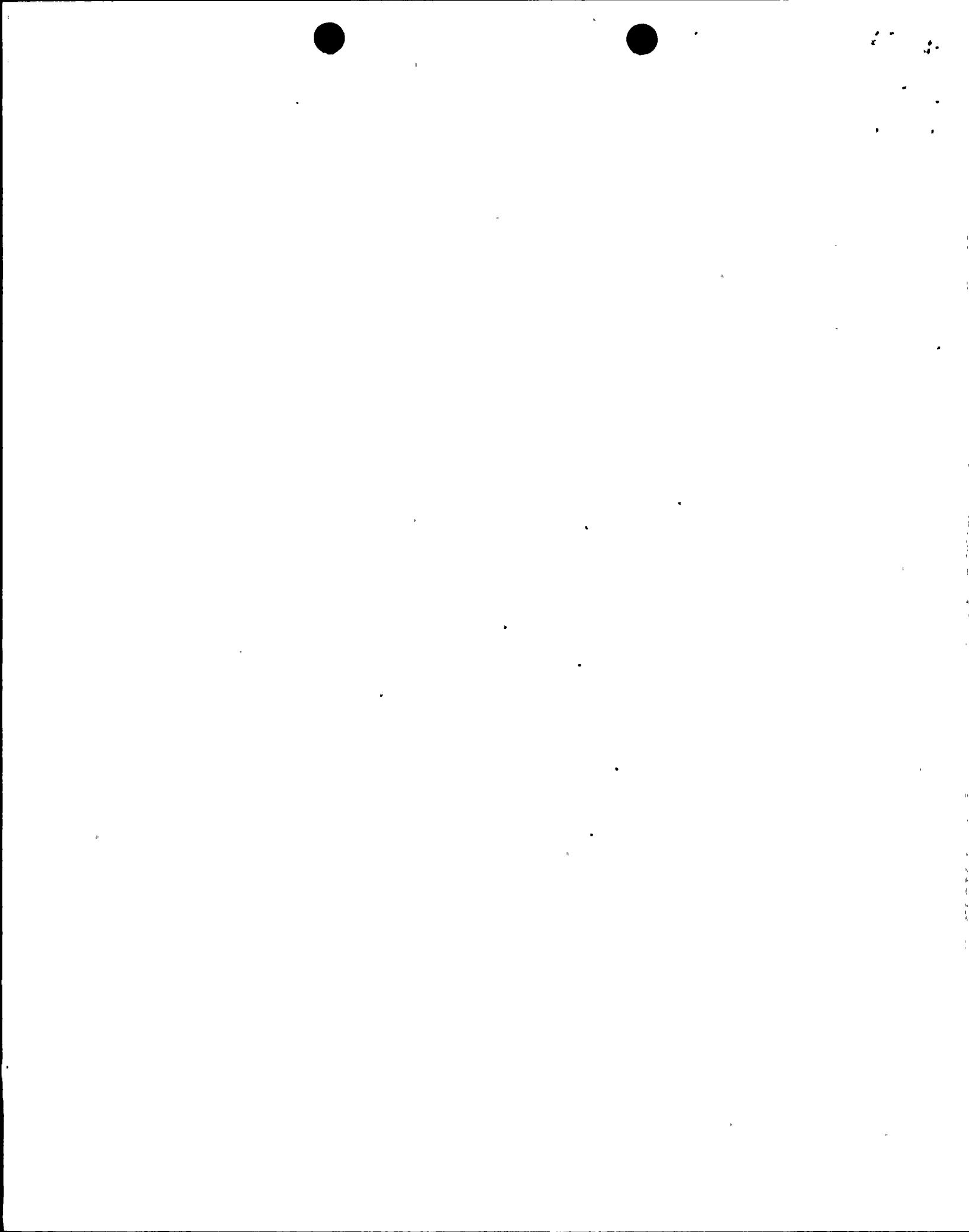
The licensee addressed applicable FRSS issues in Sections 4.8.1 and 4.8.4 of the IPPEE submittal. One of the FRSS issues addresses safety problems (e.g., inadvertent actuation of fire protection systems on safety systems) documented in GSI-57. The concern of this GSI also includes seismically induced fires, seismically induced suppressant diversion, and seismically induced actuation of fire protection systems. The staff finds that the licensee's GSI-57 evaluation acceptable and the staff considers this issue resolved for Palo Verde.

2.4.5 Fire Risk Scoping Study Issues

The licensee addressed FRSS issues in Section 4.8 of the IPPEE submittal. These FRSS issues include (1) seismic/fire interactions, (2) adequacy of fire barriers, (3) smoke control and manual fire-fighting effectiveness, (4) equipment survival in a fire-induced environment, and (5) fire-induced alternate shutdown/control room panel interaction. The staff finds that the licensee's evaluation is consistent with the guidance provided in Section 6.2.2.2 of NUREG-1407, and, therefore, the staff considers this issue resolved for Palo Verde.

2.5 Other Generic Safety Issues

In addition to those USIs and GSIs discussed above that were explicitly requested in Supplement 4 to GL 88-20, four GSIs were not specifically identified as issues to be resolved under the IPPEE program; thus, they were not explicitly discussed in Supplement 4 to GL 88-20 or NUREG-1407. However, subsequent to the issuance of the GL, the NRC evaluated the scope and the specific information requested in the GL and concluded that the plant-specific analyses being requested in the IPPEE program could also be used, through a satisfactory IPPEE submittal review, to resolve the external event aspects of these four GSIs. These GSIs were initially evaluated by the NRC's contractors and the results of these evaluations are contained in the attached TERs. For those GSIs that were not completely



resolved by the NRC's contractors, the NRC staff performed additional reviews in order to arrive at a satisfactorily conclusion. The final resolution of these issues is provided below.

2.5.1 GSI-147, "Fire-Induced Alternate Shutdown/Control Room Panel Interactions"

The licensee addressed applicable FRSS issues in Section 4.8 of the Palo Verde IPEEE submittal. One of the FRSS issues addresses safety problems documented in GSI-147. The licensee's FRSS evaluation addresses applicable issues of GSI-147 through the fire response and scenario analysis of MCR fires (Sections 4.8.5 and 4.6.3.2 of the Palo Verde IPEEE submittal). Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential vulnerabilities associated with this issue. On the basis that no potential vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved for Palo Verde.

2.5.2 GSI-148, "Smoke Control and Manual Fire-Fighting Effectiveness"

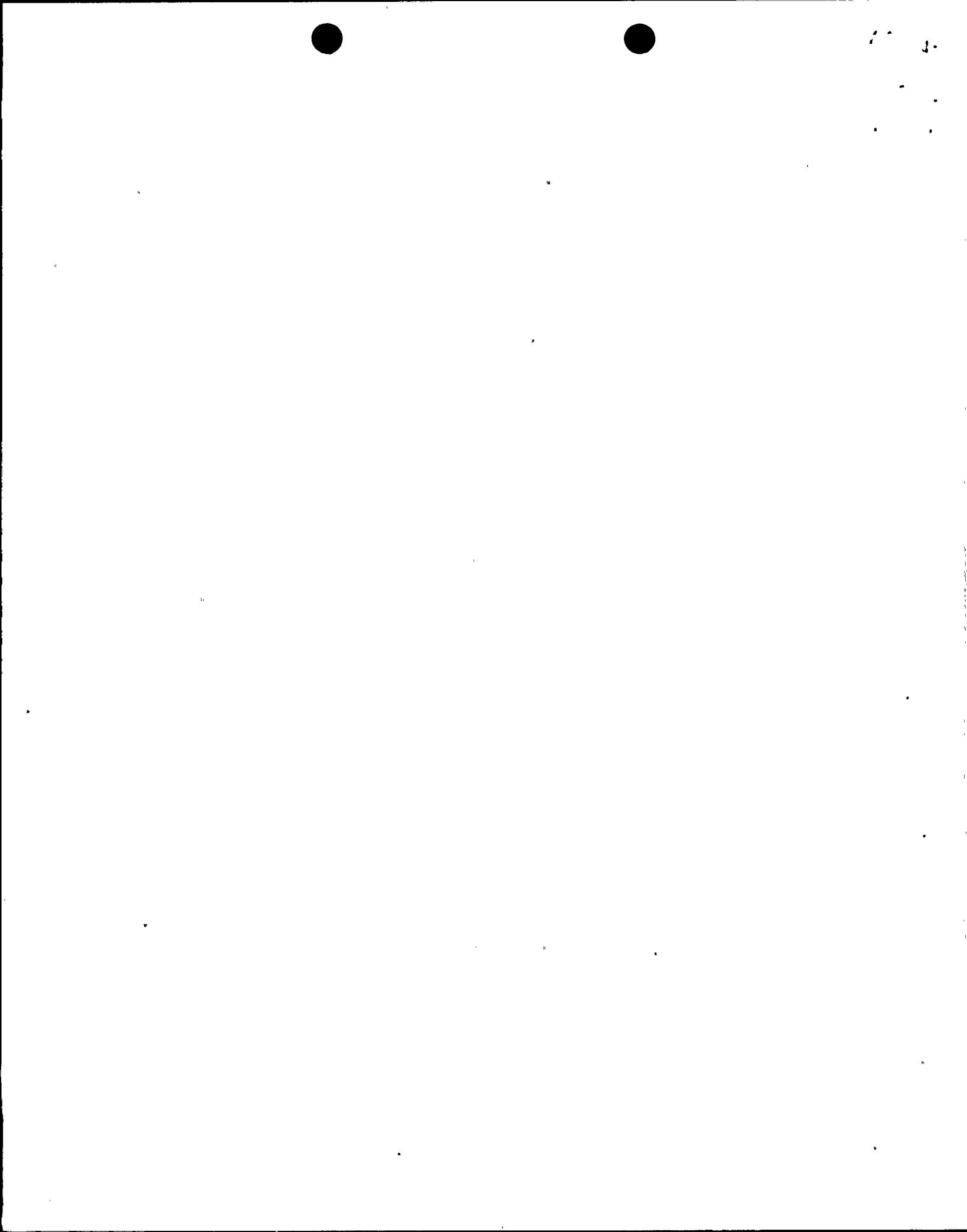
The licensee addressed applicable FRSS issues in Section 4.8 of the Palo Verde IPEEE submittal. One of the FRSS issues addresses safety concerns documented in GSI-148. The licensee's FRSS evaluation addresses the applicable issues of GSI-148 in Sections 4.8.3 and Section 4.8.4 of the Palo Verde IPEEE submittal. Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential vulnerabilities associated with this issue. On the basis that no potential vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved for Palo Verde.

2.5.3 GSI-156, "Systematic Evaluation Program (SEP)"

Palo Verde does not belong to the SEP group of plants. Therefore, GSI-156 is not applicable.

2.5.4 GSI-172, "Multiple System Responses Program (MSRP)"

The licensee's IPEEE submittal contains information addressing the following external events-related MSRP issues: (1) effects of fire protection system actuation on non-safety-related and safety-related equipment (Section 4.8.4.2), (2) seismically induced fire suppression system actuators (Section 3.1.1), (3) seismically induced fires (Section 3.1.1), (4) effects of hydrogen line rupture (Section 4.2), (5) the IPEEE-related aspects of common cause failures related to human errors (Section 4.6.3.2), (6) non-safety-related control system/safety-related system dependencies (Section 3.1), (7) effects of flooding and/or moisture intrusion on non-safety-related and safety-related equipment (Section 5.2), (8) seismically induced spatial/functional interactions (Section 3.1.1), (9) seismically induced flooding (Section 3.1.1), (10) seismically induced relay chatter (Section 3.1.2), and (11) evaluation of earthquake magnitude greater than safe shutdown earthquake (Sections 3.1.3 and 3.1.4). Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential external vulnerabilities associated with this issue. On the basis that no potential vulnerability associated with this issue was identified in the IPEEE submittal, the staff considered the IPEEE-related aspects of this issue resolved for Palo Verde.



2.6 Unique Plant Features, Potential Vulnerabilities, and Improvements

Palo Verde is located in a relatively moderate seismicity region in the western United States (a 0.3g focused scope plant) and was designed in accordance with modern seismic engineering principles and standards. The licensee stated that a seismic vulnerability would exist if the seismic capacity of the components on the highest capacity branch on either SPLD was determined to have an HCLPF value of less than the RLE of 0.3g. Using this criterion, the licensee did not identify any seismic vulnerabilities. However, the licensee's IPEEE walkdowns identified a limited number of actions that were taken in the seismic area (e.g., the anchorage on the bookshelves located behind the control cabinets in Unit 3 was improved to reduce the possibility that the cabinet would be impacted during a seismic event).

The licensee defined a potential fire vulnerability for Palo Verde to exist if core damage sequences were identified that were in excess of 1E-6 per RY and that resulted in containment failure sequences that were unique or unbounded by similar sequences contained in the IPE. No fire vulnerabilities were identified by the licensee. However, the licensee implemented certain plant improvements to address some weaknesses in the fire area. These plant improvements were (1) installation of a remote disconnect switch to the essential air cooling unit for the Train B DC equipment rooms, (2) reconfiguration of the fire damper control panels and separation of the damper actuation circuitry so that a fire in the Train B switchgear room would not cause a loss of cooling to Train A switchgear and DC equipment rooms, and (3) installation of additional separate fuses to safe shutdown circuits so that a single fire in a certain common area would not cause loss of control power to safe shutdown circuits of both trains of the essential ESF switchgear rooms at Palo Verde.

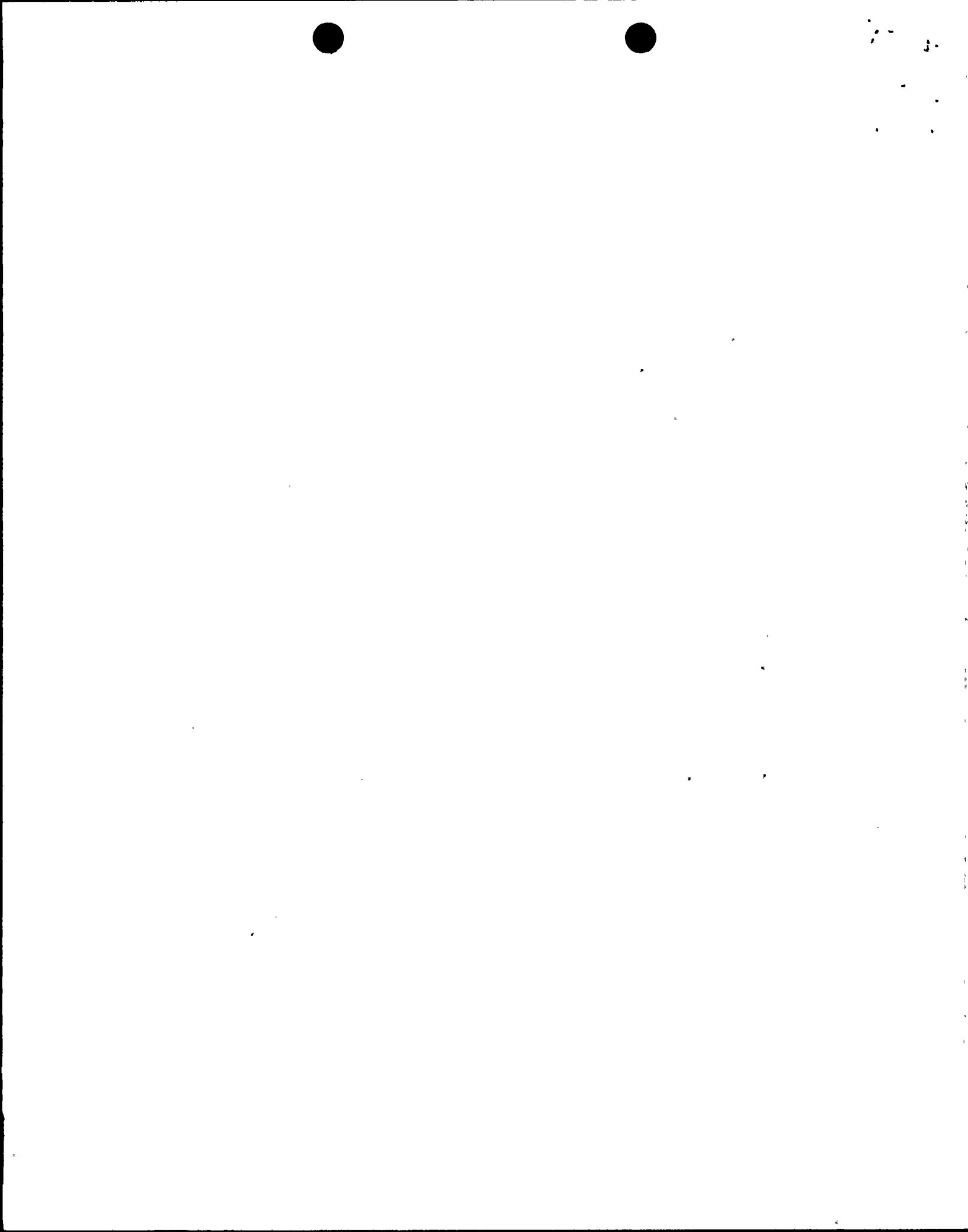
3.0 CONCLUSIONS

On the basis of the above findings, the staff notes that (1) the licensee's IPEEE is complete with regard to the information requested by Supplement 4 to GL 88-20 (and associated guidance in NUREG-1407), and (2) the IPEEE results are reasonable given the Palo Verde design, operation, and history. This conclusion is based on the findings as presented in the attached TERs and the additional reviews conducted by the NRC staff. Therefore, the staff concludes that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the Palo Verde IPEEE has met the intent of Supplement 4 to GL 88-20 and the resolution of specific generic safety issues discussed in this evaluation report.

It should be noted that the staff focused its review primarily on the licensee's ability to examine Palo Verde for severe accident vulnerabilities. Although certain aspects of the IPEEE were explored in more detail than others, the review was not intended to validate the accuracy of the licensee's detailed findings (or quantitative estimates) that underlie or stem from the examination. Therefore, this evaluation report does not constitute NRC approval or endorsement of any IPEEE material for purposes other than those associated with meeting the intent of Supplement 4 to GL 88-20 and the resolution of specific generic safety issues discussed in this Evaluation report.

Principal Contributor: E. Chelliah

Date: July 2, 1999



4.C REFERENCES

1. Nuclear Regulatory Commission (U.S.) (NRC). Generic Letter 88-20, Supplement 4, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - Title 10 CFR 50.54(f)." NRC: Washington, D.C. June 28, 1991.
2. Stewart, W.L., Arizona Public Service Company (APS), letter to Document Control Desk (DCD), NRC. "Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 - Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities (Generic Letter No. 88-20, Supplement 4)," June 30, 1995.
3. Thomas, K.M., NRC, letter to J.M. Levine, APS. "Request for Additional Information Regarding Individual Plant Examination of External Events Submittal for the Palo Verde Nuclear Generating Station," October 23, 1997.
4. Ide, W.E., APS, letter to DCD, NRC. "Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 - Response to Request for Additional Information Regarding Individual Plant Examination of External Events Submittal for the PVNGS," February 27, 1998.
5. Electric Power Research Institute (EPRI). "A Methodology for Assessment of Nuclear Power Plant Seismic Margin." EPRI-NP-6041-SL, Revision 1. August 1991.

Attachments:

Appendix A: Submittal-Only Screening Review of the Palo Verde Nuclear Generating Station Individual Plant Examination for External Events (Seismic Portion), March 1999

Appendix B: Fire Submittal Screening Review - Technical Evaluation Report: Palo Verde (Individual Plant Examination - External Events), Revision 5, September 9, 1998

Appendix C: Technical Evaluation Report on the Review of the Palo Verde Nuclear Generating Station, Units 1, 2, 3, Individual Plant Examination for External Events (IPEEE) Submittal on High Winds, Floods, and Other External Events (HFO), April 1999