ES96-005666

The Under Secretary of Energy
Washington, DC 20585

March 28, 1996

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

As you are aware, technical evaluations at the Savannah River Site prepared in support of improvements to the H-Canyon Facility Safety Authorization Basis indicate that seismic analyses used as the basis for the existing Safety Analysis Report (SAR) do not reflect as-built conditions and contain certain assumptions that may tend to overstate the capability of H-Canyon to withstand a severe earthquake. F-Canyon is similar to H-Canyon in both design and construction. Recent initial simplified scoping calculations did not demonstrate that the canyon facilities could withstand the applicable Evaluation Basis Earthquake (EBE) without collapse. More rigorous analyses to fully define the canyon facilities' response to the applicable EBE, as well as revised risk calculations utilizing improved dispersion models and assumptions, are ongoing and are expected to be completed in July.

On March 15, 1996, following an initial review of the situation, the Department temporarily suspended the introduction of additional nuclear materials (Mark-31 target slugs and plutonium 238) into the canyon facilities until a more thorough review could be completed. However, activities in the canyons to stabilize solutions, Mark-31 target slugs, and plutonium 238 already in the canyons are continuing.

A more thorough review has now been completed, which is described in the enclosed documents. I am providing this further report so that you are in possession of all the information we have to date. I would appreciate knowing whether this further analysis in any way affects your previously expressed views about proceeding with the planned stabilization program, including the introduction of new material into the canyons for this purpose.

Thomas P. Grumbly
Acting Under Secretary

Enclosure

DOE F 1325.8 (8-89)

United States Government Department of Energy (DOE)

memorandum

Savannah River Operations Office (SR)

DATE: MAR 27 1996

REPLY TO ATTN OF: TECH (Waltzer, 803-952-4121)

SUBJECT: Recommendation for Continuing with the Stabilization Program as Described in the Record of Decision (ROD) for the Final Interim Management of Nuclear Material Environmental Impact Statement (IMNM EIS)

TO: Office of the Secretary (S-3), HQ

Issue: Should DOE continue with the stabilization program as described in the ROD for the IMNM EIS and with the continuing programmatic post-Cassini mission related plutonium-238 material?

Background: On March 11, 1996, I provided you a set of recommendations for continuing scheduled canyon operations, including stabilization of all Mark-31 targets, pending the outcome of the on-going canyon seismic evaluation. On March 15, 1996, the Office of Environmental Management endorsed these recommendations with three caveats. The caveats were: a) no additional Mark-31 targets could be introduced to F-Canyon, b) no new shipments of plutonium-238 could be made to add to the existing plutonium-238 inventory in H-Area, and c) preparation should begin for implementation of appropriate source term limits in the event the introduction of new material to the canyons is authorized. These restrictions were placed with the commitment for a more thorough evaluation of the issues surrounding the introduction of new material to the canyons prior to completion of all the seismic analysis work. The expectation was this review would be completed by the end of March. A chronology of events is attached to aide in the understanding of this issue.

The focus of the issue was whether the risk from earthquakes currently presented in the IMNM EIS constituted significant changes in environmental impacts or significant, reasonably foreseeable, environmental impacts that had not been considered in the EIS. Our plan to address these concerns was included as Attachment 4 to the aforementioned March 15 correspondence. It provided a method to compare the risk which could reasonably be expected from the current SRS evaluation basis earthquake (EBE) to the risk from the EBE used in the analysis work for the Final IMNM EIS.

Discussion: The only information in the existing IMNM EIS that could be affected by the canyon seismic evaluation are the health effects associated with the earthquake accidents. Therefore, an analysis was completed to compare the risk from earthquake accidents associated with the current EBE to the risk from earthquake accidents in the IMNM EIS. The first step in the process was to estimate the earthquake the canyon would survive with no more damage than assumed in the IMNM EIS earthquake analysis. As a parallel effort, the applicable EBE for the SRS was estimated.

The preliminary results from the intensive two week review (see attachment) indicate the canyons would survive an EBE. However, the results of this effort show that the frequency of the EBE applicable to the site increased from an once in 5000-year event to an approximated once in 2000-year event. To offset the increased risk that resulted from the increased frequency the source term was reduced from 30 mega-curies (source term assumed in the IMNM EIS) to 8 mega-curies. As a result, the risk associated with the current EBE is less than or equal to the EBE risk in the IMNM EIS. Therefore, there are no significant changes relevant to the health effect impacts presented for the earthquake accidents in the Final IMNM EIS.

I believe there is an adequate level of assurance the earthquake accident health effects information in the IMNM EIS remains reliable for decision making purposes. There is no new information which should bear upon existing decisions regarding the stabilization of nuclear materials at SRS, including the Mark-31 targets, or bear upon the impacts for the actions. As such, I recommend the following:

1) Resume introduction of Mark-31 targets to F-Canyon and continue with all scheduled stabilization activities in accordance with the ROD for the IMNM EIS.

2) Resume the post-Cassini plutonium-238 receipt and processing program.

3) Reduce the current curie inventory limits for the canyon and B-Line facilities to a total of 8 million curies. These quantities will be reevaluated based on the information in the completed Safety Analysis Report.

MAR 27 1996

It is my expectation that operations would continue through, and subsequent to, the process of completing the evaluation to determine whether or not an unreviewed safety question (USQ) exists. If it is determined an USQ exists, the authorization basis will be revised appropriately. This could include the implementation of additional restrictions to maintain current risk or accepting higher risks. If accepting higher risk must be considered, I will notify your office to ensure all aspects of this decision are evaluated.

Recommendation: I request you approve these recommendations.

Mario P. Fiori
Manager

Attachment:
Chronology of Events
Seismic Risk Associated with SRS Canyons and B-Lines

Approved: __________, and I have determined that a supplemental environmental impact statement is not required at this time.

Disapproved: __________

Date: __________

CHRONOLOGY OF EVENTS

1/96 WSRC begins canyon structural analysis to support effort to upgrade Safety Analysis Report from the 1980's requirements to current DOE Orders and Standards.

2/29/96 WSRC declares a potential inadequacy in the safety analysis, as required by DOE 5480.21, based on discovery of inappropriate assumptions in the 1980's era analysis. This declaration included notification via the DOE occurrence reporting system in accordance with DOE-SR and WSRC procedures.

2/29/96 Press release, coordinated with Headquarters, is issued to explain this discovery. The press release provided a vehicle to transmit accurate and timely information regarding the potential safety implications of the analysis work and not cause any undue concern to our community.

3/11/96 Outside seismic experts visit SRS to review on-going analysis work. They conclude the structure is more robust than originally assumed and provided suggestions for incorporating additional analysis work to help demonstrate this.

3/11/96 DOE-SR recommends all stabilization activities continue pending completion of the evaluation to determine if an unreviewed safety question exists. DOE-SR conclusion is there would be no undue risk to workers or the public.

3/12/96 Seismic and structural analysis information is reviewed with the DNFSB.

3/15/96 EM-60 recommends stabilization actions should continue, but that no new material e.g., MK-31 targets, should be introduced to the canyons until a more detailed review of the current earthquake accident risk is completed. The EM-60 recommendation included the DOE-SR proposal to address this issue.

3/27/96 DOE-SR transmits risk evaluation with conclusion that risk in IMNM EIS is still representative and IMNM EIS stabilization decisions are valid.

Westinghouse
Savannah River Company

MAR 27 1996

OVP-960004

Dr. Mario P. Fiori, Manager
U. S. Department of Energy
Savannah River Operations Office
Aiken, South Carolina 29808

Dear Dr. Fiori:

SEISMIC RISK ASSOCIATED WITH SRS CANYONS AND B-LINES (U)

Recent new information concerning existing structural evaluations of the seismic capability of SRS Canyons has led to a determination that a Potential Inadequacy in the Safety Analysis (PISA) exists for F and H Canyons and F and H B-Lines. Programmatic decisions involving operations in these facilities were recently announced in Records of Decision (RODs) pursuant to the Interim Management of Nuclear Materials (IMNM) Environmental Impact Statement (EIS). The purpose of the attached paper is to document the basis for WSRC's position that:

(1) the seismic risks considered in the IMNM EIS continue to bound current expectations of seismic risk associated with SRS Canyons and B-Lines, and

(2) the current IMNM EIS continues to provide an adequate basis for the programmatic decisions announced in the RODs.

For reasons discussed in the attached paper and summarized below, WSRC recommends the following:

1. Continue implementation of all currently authorized operations in the F and H Canyons and F and H B-Lines.

2. Resume shipments of irradiated Mk-31 targets from storage basins to F-Canyon and complete planned stabilization activities.

3. Receive remaining Pu-238 receipts from offsite and complete planned post-Cassini processing activities.

4. Complete the remaining phases of the overall seismic/structural evaluation of the canyon buildings and the associated Unreviewed Safety Question Evaluation on the established aggressive schedule.

UNCLASSIFIED
DOES NOT CONTAIN
UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION
ADC & Reviewing Official: D. E. Burton, Restart Mgr
(Name and Title)
Date 3-27-96

UNCLASSIFIED
DOES NOT CONTAIN
UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION
ADC & Reviewing Official: J. W. McClard, Tech Ad.

A detailed structural evaluation of the H Canyon building is currently underway to support preparation of an updated Safety Analysis Report (SAR). This detailed structural evaluation is being conducted in several phases in accordance with applicable DOE Orders and Standards. During the initial phase of the current evaluation, review of previous structural evaluations from 1981-1984 revealed inaccuracies in those previous evaluations. Since the projection of seismic risk presented in existing SARs for both F and H Canyons and F and H B-Lines was based in part upon conclusions from the 1981-1984 structural evaluations, the new information regarding inaccuracies in those evaluations led to the determination that a Potential Inadequacy in the Safety Analysis (PISA) exists. The PISA was reported per DOE Order 232.1 requirements on March 1, 1996.

At that same time, a summary of this new information and of preliminary results from the initial phase of the current structural evaluation of the canyon buildings was provided to the public and interested stakeholders. The initial phase of the current evaluation employed very conservative inputs (such as minimum design strengths for concrete and reinforcing steel) and has not demonstrated the required seismic capability in response to an Evaluation Basis Earthquake (EBE). This result is not totally unexpected at this stage in the evaluation process for existing structures such as the canyon buildings.

DOE Standard 1020 describes the overall evaluation methodology, which includes subsequent conduct of a more rigorous analysis employing more representative inputs (such as actual concrete strengths determined from representative sampling) if required to demonstrate adequate capability for existing structures. The next phase of the analysis will also include consideration of building drift (projected lateral displacement of the floors and roof slab). Early estimates predict building drift values within the range of acceptability. WSRC has established an aggressive schedule to complete the remaining phases of the overall evaluation by July 1996. Results will be evaluated per DOE Order 5480.21 requirements to determine if an Unreviewed Safety Question (USQ) exists. The outcome of this USQ Evaluation is also expected by July 1996 and will determine whether revisions are needed to the Authorization Bases.

The WSRC position and recommendations presented above are pursuant to the following summary conclusions drawn from the attached discussion.

- WSRC engineers and outside technical expert reviewers believe that the analyses to be conducted in the remaining phases of the overall seismic/structural evaluation will more accurately predict the seismic capability of the canyon buildings and should demonstrate adequacy for postulated EBE ground motion.

- If the canyon buildings are shown to be capable for the site EBE, the conservative projections of seismic accident consequences in existing Authorization Basis documents and the IMNM EIS remain valid.

- Risk projections associated with ongoing and planned facility operations based on the expected frequency of the site EBE remain within the bounds of those presented in the IMNM EIS. The seismic component represents only about 20% of the overall risk projections.

- Estimates of both individual prompt fatality risk and individual latent cancer fatality risk associated with the unlikely event of collapse of the canyon buildings are within the respective limits for nuclear facility severe accident impacts established by DOE policy. These calculations used a facility inventory input which bounds the inventories expected during completion of material stabilization operations as described in the DOE 94-1 Implementation Plan and planned post-Cassini Pu-238 processing (including receipt of remaining returns).

If you or your staff have any questions, please contact me or Frank Jordan, ext. 2-4409, of my staff.

Yours truly,

J. J. Buggy
Executive Vice President

JED:jcc

cc: Distribution

LETTER, OVP-960004, J. J. BUGGY, TO M. P. FIORI, DOE, SEISMIC RISK ASSOCIATED WITH SRS CANYONS AND B-LINES (U), DATED MAR 27 1996

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Continued Applicability of IMNM EIS Consideration of Seismic Risk Associated with SRS Canyons and B-Lines

Purpose

Recent new information concerning existing structural evaluations of the seismic capability of SRS Canyons has led to a determination that a Potential Inadequacy in the Safety Analysis (PISA) exists for F and H Canyons and F and H B-Lines. Programmatic decisions involving operations in these facilities were recently announced in Records of Decision (RODs) pursuant to the Interim Management of Nuclear Materials (IMNM) Environmental Impact Statement (EIS). The purpose of this paper is to document the basis for WSRC's position that:

(1) the seismic risks considered in the IMNM EIS continue to bound current expectations of seismic risk associated with SRS Canyons and B-Lines, and

(2) the current IMNM EIS continues to provide an adequate basis for the programmatic decisions announced in the RODs.

Background

New information has revealed inaccurate assumptions in the structural evaluations of the canyon buildings. The structural evaluations in question were performed in 1981 - 1984 and provide the bases for projecting the response of these structures to seismic events considered in existing Safety Analysis Reports (SARs). The information in the canyon SARs relative to the effect of seismic events provided input for the earthquake risks presented in the IMNM EIS. The new information acquired from recent re-review of these structural evaluations calls into question certain evaluation techniques and building joint capacity assumptions which are not supported by as-constructed building details. The significance of this new information is such that a Potential Inadequacy in the Safety Analysis (PISA) exists for F and H Canyons and F and H B-Lines. This PISA was reported per DOE Order 232.1 requirements on March 1, 1996.

The conclusion of the 1981 - 1984 structural evaluations was that the canyon structure marginally meets the no-collapse criteria for an Evaluation Basis Earthquake (EBE). This conclusion forms the basis for SAR determinations of potential radiological release consequences from accidents initiated by the EBE. A detailed structural evaluation of the H-Canyon building is currently underway to support an updated Safety Analysis Report. The initial phase of this new evaluation included a review of the 1981-1984 structural evaluations. This review revealed the new information described above. Since H-Canyon and F-Canyon are similar structures, this information is considered applicable to both facilities.

The current structural evaluation is being conducted in several phases in accordance with applicable DOE Orders and Standards. The initial phase of this new evaluation employed very conservative inputs (such as minimum design strengths for concrete and reinforcing steel) and has not demonstrated the required seismic capability in response to an Evaluation Basis Earthquake (EBE). This result is not totally unexpected at this stage in the evaluation process for existing structures such as the canyon buildings. DOE Standard 1020 describes the overall evaluation methodology, which includes subsequent conduct of a more rigorous analysis employing more representative inputs (such as actual concrete strengths determined from representative sampling) if required to demonstrate adequate capability for existing structures. WSRC has established an aggressive schedule to complete the remaining phases of the overall evaluation by July 1996. Results will be evaluated per DOE Order 5480.21 requirements to determine if an Unreviewed Safety Question (USQ) exists. The outcome of this USQ Evaluation is also expected by July 1996 and will determine whether revisions are needed to the Authorization Bases.

Current Expectation of Seismic Capability of the Canyon Buildings

As indicated above, results from the initial phase of the current structural evaluation indicate that the seismic capability of the canyon structure may be lower than that indicated in the existing Authorization Basis documentation. The existing Authorization Basis acceptance criterion for the postulated seismic event is a no-collapse criterion. WSRC engineers and outside technical expert reviewers believe that the analyses to be conducted in the remaining phases of the overall seismic/structural evaluation will more accurately predict the seismic capability of the canyon building and should demonstrate adequacy for the postulated EBE ground motion.

The H-Canyon building is a reinforced concrete structure with walls up to 4.5 feet thick. The initial phase analyses specify minimum design strength of the concrete and reinforcing steel. The actual strength of concrete and reinforcing steel are greater than the minimum design values, and concrete strength increases with age. A sample of concrete strengths from the H-Canyon in the 1980's indicates an average strength 44% greater than the minimum specified design strength. Updated concrete and steel strengths from the H-Canyon structure will be obtained and will be used in the remaining analyses. Other factors that will be used in the remaining analyses include the relaxation of specified resistance factors, which is appropriate when evaluating an existing structure, the use of strain hardening of the reinforcing steel, the use of non-linear dynamic analyses, and the specification of drift limits that are consistent with the response spectrum of the site EBE. This evaluation methodology has been discussed with outside technical experts and is deemed to constitute a valid approach to estimate the collapse load for the H-Canyon building.

The outside technical experts are Professor Charles Miller of The City College of New York (CCNY), a consultant to the DOE, and Professor Mete A. Sozen of Purdue University, a consultant to WSRC. The experts participated in a review at SRS on March 7 and 8. They reviewed the construction drawings, the results from the initial analysis, and the plans for the remaining analyses. Trip reports were prepared by both experts; Dr. Sozen wrote in his report that "The probability is very high that the integrity of the structure will not be adversely affected during the ground motion anticipated". Dr. Miller wrote in his trip report that based on estimated drift calculations, "it was concluded that the building was unlikely to collapse under the evaluation earthquake." Both of these reports are attached in Appendix A.

Continued Applicability of the IMNM EIS

The conservative projections of seismic accident consequences in existing Authorization Basis documents and the Interim Management of Nuclear Materials (IMNM) Environmental Impact Statement (EIS) are predicated upon the assumption that the canyon buildings meet the no-collapse criterion for an EBE. If the canyon buildings are shown to be capable for the site EBE, the conservative projections of seismic accident consequences in existing Authorization Basis documents and the IMNM EIS remain valid.

The contribution of potential seismic events to the overall risk associated with canyon inventories and operations is determined by examining the consequences associated with post-accident behavior of source materials and the expected occurrence frequency of the EBE. Current DOE Orders and Standards, issued within the past ten years, require an expected return frequency of 2000 years for the EBE used for evaluation of structures like the F and H Canyons (see discussion in Appendix B). The existing Authorization Basis documentation uses an expected EBE return frequency of 5000 years. The effect of this change in EBE frequency is best understood by examining how current projections of seismic risk (based on canyon inventory and the new EBE frequency) compare with those presented in the existing Authorization Basis documentation and the IMNM EIS.

Risk projections associated with ongoing and planned facility operations based on the expected frequency of the site EBE remain within the bounds of those presented in the IMNM EIS. Calculations were performed (see discussion in Appendix C) to reassess the estimates for latent cancer fatalities presented in the EIS. These calculations used a facility inventory input which bounds the inventories expected during completion of authorized material stabilization operations and authorized post-Cassini Pu-238 processing (including receipt of remaining returns). The seismic component represents only about 20% of the overall risk projections.

Best Estimate of Risk Associated With Collapse of the Canyon Buildings

To provide additional perspective, a best estimate has been made of the risk associated with the unlikely event of collapse of the canyon buildings. The estimates for both individual prompt fatality risk and individual latent cancer fatality risk are within the respective DOE safety goals (see discussion in Appendix D).

Summary and Conclusion

The discussion contained herein and the expanded discussion contained in the appendices can be summarized as follows:

- WSRC engineers and outside technical expert reviewers believe that the analyses to be conducted in the remaining phases of the overall seismic/structural evaluation will more accurately predict the seismic capability of the canyon buildings and should demonstrate adequacy for postulated EBE ground motion.

- If the canyon buildings are shown to be capable for the site EBE, the conservative projections of seismic accident consequences in existing Authorization Basis documents and the IMNM EIS remain valid.

- Risk projections associated with ongoing and planned facility operations based on the expected frequency of the site EBE remain within the bounds of those presented in the IMNM EIS. The seismic component represents only about 20% of the overall risk projections.

- Estimates of both individual prompt fatality risk and individual latent cancer fatality risk associated with the unlikely event of collapse of the canyon buildings are within the respective limits for nuclear facility severe accident impacts established by DOE policy. These estimates provide additional perspective but have no direct bearing on the applicability of the IMNM EIS since all analyses in the EIS assume that the canyons will withstand an EBE.

WSRC concludes that the seismic risks considered in the IMNM EIS continue to bound current expectations of seismic risk associated with SRS Canyons and B-Lines and that the IMNM EIS continues to provide an adequate basis for the programmatic decisions announced in the associated Records of Decision.

Recommendations

1. Continue implementation of all currently authorized operations in the F and H Canyons and F and H B-Lines.

2. Resume shipments of irradiated Mk-31 targets from storage basins to F-Canyon and complete planned stabilization activities.

3. Receive remaining Pu-238 receipts from offsite and complete planned post-Cassini processing activities.

4. Complete the remaining phases of the overall seismic/structural evaluation of the canyon buildings and the associated Unreviewed Safety Question Evaluation on the established aggressive schedule.

Appendix A

Discussion of the Expected Acceptability of the Building 221 Canyon Structures

Westinghouse Savannah River Company engineers are continuing the evaluation program for the Building 221 Canyon structures. At this time there is a significant amount of work to complete before a definitive statement of the seismic level associated with a no-collapse criterion can be made. However, based on applying a drift limit criterion, and conducting a more rigorous analysis employing more representative inputs than used in the initial phase analysis, WSRC expects with high confidence that the building structure will be shown to be capable for the current site EBE. The basis for confidence is given below.

Results from the initial phase of the current structural evaluation indicate that the 221 Canyon buildings may not meet the Authorization Basis no-collapse criterion. This preliminary judgment was based on a static non-linear push over analysis. The remaining analyses will use non-linear dynamic time history analysis techniques. Application of these techniques is expected to show a reduced demand on the building structure. Furthermore, the collapse mechanism involves a highly redundant sequence of building joint rotations along with the simultaneous formation of a sufficient number of hinges. A collapse mechanism is not expected to form when the non-linear building model is evaluated using a time history ground motion.

To obtain an accurate estimate of the building collapse load, the more rigorous remaining analyses in the overall evaluation process will include:

(1) rotation hinge models based on strain hardened material properties,
(2) in-situ concrete strengths,
(3) increasing the American Concrete Institute (ACI) code strength reduction factors consistent with Chapter 20 of ACI 318, 1995,
(4) empirical joint behavior, and
(5) hysteresis modeling of the rotation hinges.

While non-linear time history analysis and refined structural models are expected to show the building capable of sustaining a seismic motion greater than the initial phase calculations predict, the final results will also include consideration of building drifts. The estimated drift of the canyon buildings between the top of the basemat and the lower level of the roof is 3.8 inches, based on a lower bound building structural frequency of 1.4 Hz (i.e., reducing the building stiffness by one half), and using the current site EBE 2% damped free-field spectrum. This drift is 0.48% of the height of the building. The 1994 National Earthquake Hazard Reduction Program (NEHRP) Recommended Provisions allow drifts of 1% for essential buildings constructed as moment resisting frame structures. Building 221 is a moment resisting concrete frame. Essential buildings are those required for post-earthquake recovery and are expected to remain standing and function after an earthquake. With drift limits on the order of 1% or 7.9 inches for the canyon structure, it is expected that the amount of rotation in the building members where non-linear hinges form will be small, and reinforcing steel bond slip will not initiate generalized non-ductile behavior. The remaining analyses will apply non-linear dynamic time history modeling to calculate building drifts and the resulting joint rotations from the site EBE ground motion. Results from these analyses are expected to confirm the acceptability of the Canyon buildings for the Authorization Basis no-collapse criterion.

As further indication that the canyon buildings are expected to remain standing for drifts from a site EBE, a review of the technical literature suggests that reinforced concrete frames detailed for gravity loads attain drifts of between 1% and 3% before failure [A-1, A-2, A-3]. The canyon structure is a reinforced concrete frame in its transverse direction and is expected to have drifts less than 1% for the site EBE.

Concurrent with the ongoing building structural evaluation, a revised site ground motion is being developed according to DOE Standard 1023 using the latest Electric Power Research Institute (EPRI) and Lawrence Livermore National Laboratory (LLNL) probabilistic rock hazard curves for SRS. Preliminary information suggests that the drifts for the canyon buildings will be lower for the new ground motion than those predicted above using the current site EBE ground motion. For example, the drift between the top of the basemat and the top of the lower roof is estimated to be 1.1 inches for a 2000-year return period ground motion compared to 3.8 inches for the current site EBE.

The preliminary structural analyses were reviewed by Professor Mete A. Sozen of Purdue University and Professor Charles Miller of CCNY at SRS in early March of this year. The observations made by Professor Sozen during his review of the evaluation program are significant in predicting that the Canyon buildings will maintain structural integrity for ground motions such as the current site EBE. The following excerpt from Professor Sozen's trip report is pertinent:

(a) "High ratio of supporting-element cross-sectional area to supported floor area. (For example, this ratio is approximately 4% at elev. 357'.) In a typical low-rise building, that would suggest light or no damage in the event of a strong ground motion...

(b) Low axial-load stress in the vertical elements suggesting the unlikelihood of brittle failure associated with crushing of concrete.

(c) Low longitudinal-reinforcement ratios in all elements suggesting the unlikelihood of brittle failures associated with shear."

Both reviewers believe that the potential for the canyon buildings to fail by collapse during an earthquake ground motion such as the site EBE is highly unlikely. The complete trip reports by Professor Sozen and Professor Miller are attached to this letter.

References

A-1. Beres, White and Gergely, "Seismic Performance of Interior and Exterior Beam-to-Column Joints Related to Lightly Reinforced Concrete Frame Buildings: Detailed Experimental Results," NCEER 92-007, National Center for Earthquake Engineering Research, State University of New York at Buffalo, New York, 1992.

A-2. Eligehausen, E., E. P. Popov, and V. V. Bertero, "Local Bond Stress-Slip Relationships for Deformed Bars under Generalized Excitations, Experimental Results and Analytical Model", Report No. UCB/EERC-83/23, October, 1983.

A-3. Paulay, T., and M. J. N. Priestley, "Seismic Design of Reinforced Concrete and Masonry Buildings", John Wiley, 1992.

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March 11, 1996

Dr. Kamal Bandyopadhyay
Brookhaven National Laboratory
Engineering Research and Applications Division
Building 475-C
Upton, NY 11973

Subject: Trip report for March 7-9, 1996 visit to Savannah River regarding Building 221-H

Dear Kamal:

Dr. M. Davister of DOE and I visited the Savannah River site on March 7-8, 1996 to discus the planned program to determine the seismic capability of Building 221-H (the H-Canyon structure). Savannah River (SR) staff attending the meeting were : T. Houston, N. Kennedy, F. Loeef, G. Mertz, and J. Mulliken. Dr. Mete Sozen of Purdue also attended the meeting acting as a consultant to SR.

The H-Canyon was designed in the early 1950s based on a 0.1 G ZPA Uniform Building Code criteria. Several seismic analyses have been performed since that time. These analyses have been recently reviewed by SR resulting in the conclusion that it is unlikely that the building satisfies the current DOE 1020 seismic criteria. The building is classified as a PC-3. The expected use of the building is to reprocess material at SR with an expected mission length of about 5-6 years. The building will likely be decommissioned at the end of the mission.

The reinforced concrete structure consists of eighteen segments arranged in series (in the N-S direction) with each segment separated by a 1/2" unreinforced construction joint. Each segment is 122' wide (in the E-W direction) and 43' long. The building is 71' high and is embedded about 20' in the soil. Many of the segments have a penthouse on the roof. The penthouse is 67' wide and 38' high. Primary longitudinal (N-S) lateral stiffness comes from 4' thick shear walls .while the transverse (E-W) stiffness is provided by reinforced concrete frames. Details of much of the reinforcement in these frames do not satisfy ACI code development length requirements. The seismic weakness of the building in the E-W direction results from these joints. SR is focusing there efforts on this problem.

SR is performing a traditional elastic analysis as required in DOE 1020. This has not been completed but it is clear that the result will be that the building has a seismic capability in the range of 0.05 G ZPA. This low value is the result of the poor detailing of the joints in the E-W moment frames.

SR's main effort is now directed toward an evaluation of the collapse earthquake. To this end they have completed a push-over analysis and determined a static collapse load for one of the segments deemed to be critical. The joints which do not have proper detailing were modeled by scaling the yield strength of the steel in proportion to the ratio of the development length provided to the ACI code required length. The nonlinearity in the joint moment-rotation relationship was modeled with a rotational spring placed between the end of the member and the joint. Static loads were applied proportional to the building mass with the distribution of the loads over the height of the building selected to match the UBC floor shear distribution. Two solutions were generated: one with soft foundation springs resulting in significant differential settlements and the other with no differential settlements. The following items were discussed at the meeting:

1. The static collapse loads were found to be equivalent of 0.09 G's and 0.082 G's for the cases neglecting and including differential settlements. The corresponding peak roof displacements were found to be 0.2 feet and 0.37 feet respectively for the two cases. The drift (roof displacement relative to the foundation displacement) for the two cases is about the same with the difference between the two displacement resulting from differential settlements.

2. The maximum inelastic rotation at the joints (at the 0.2 feet drift) was found to be about 0.015 radians.

3. Based on these results and experimental data for similar problems, Sozen estimated that the evaluation earthquake (ZPA = 0.19 G) would cause the peak roof displacement relative to the foundation (drift) to be about 2". This corresponds to a drift of about 2/71*12 = 0.2 %. Based on this result and the corresponding inelastic rotation demand of about 0.015 radians it was concluded that the building was unlikely to collapse under the evaluation earthquake.

4. Soil settlements and basemat yielding seem to have a significant impact on the results largely

because very soft Winkler springs are used to model the soil. This model results in significant basemat cracking under dead loads but there is no such evidence of cracking. It was suggested that the soil data be reviewed to obtain a more realistic foundation model and that in the interim the settlements be neglected in the seismic analyses. The following reasons support the neglect of these settlements: (a) the lack of evidence of basemat cracking indicates that the foundation springs are actually stiffer than are being used; (b) dynamic springs should be used for the seismic problem and these are likely to be much stiffer than the static springs thereby reducing the effects of differential settlements; and (c) creep effects in the concrete will reduce the static stresses in the frame due to the settlements and as a result these stresses should not be directly added to the seismic stresses.

The following path forward was therefore recommended:

1. Perform response analyses with a single degree of freedom system. The static load-deflection curve will be used to characterize the stiffness of the SDOF. This will require that some form of hysteretic load-unload characteristics be added to the model. Consideration must be given to the load-unload characteristics that would be appropriate for the underdeveloped joints where the inelastic response is associated with bond slip. Since the post elastic resistance of such joints is associated with frictional forces, recovery of deformations may not occur. The possibility of ratcheting should be evaluated.

   The current structural model includes a moment capacity at all joints with the capacity of the joints with poor detailing reduced as discussed above. It was recommended that the results of the current analyses be reviewed with the objective of assigning zero moment capacity to those joints which have large inelastic rotation demands and which may not be essential to the overall capacity of the structure. The objective of this exercise would be to eliminate from the analysis as many questionable joints as possible. Some form of parametric study should be considered in this regard.

   Since the response will include a significant inelastic component, several earthquake records should be used. The was some discussion as to whether these records should be synthetic records which fit the criteria spectra or actual earthquake records scaled to match the criteria spectra in the critical frequency range (1-4 cps probably). I would recommend that we use records which fit a deaggregated criteria spectra.

   The interesting results of these analyses will be values of the story drift and the inelastic rotation demand at the joints.The latter will require some post processing to go from the SDOF displacement to joint response by looking at the static ABAQUS solutions.

2. Perform a dynamic inelastic response analysis with the full structural model such as was used to generate the static force - deflection curve. The results of the SDOF solutions will be used to select the appropriate model to use (e.g., which joints to assign zero moment capacity) and to restrict the total number of earthquakes that need to be considered.

3. The only significant issue for the longitudinal response is the impact that may occur because of the one half inch gaps between segments. The gaps are almost certain to close when subjected to the evaluation earthquake. It was generally concluded that such impacts would only cause local damage which would not be significant for the collapse criteria being considered. The one exception pointed out by SR is the end wall which appears to be poorly anchored. This will be considered with a series of SDOF models connected at the masses with gap elements modeling the impact process.

Sincerely,

Charles A. Miller

Appendix A
Attachment 2

facsimile
TRANSMITTAL

to: Fred Loceff
fax #: 803-952-7293
re: SRS Building 221-H
date: March 14, 1996
pages: 3, including this cover sheet.

I am writing to summarize some preliminary impressions of our discussions during the meetings of 8 and 9 March 1996 at the Savannah River Site and to make a few general suggestions for the analyses to be undertaken.

My comments refer specifically to Section 6 of Building 221-H. Because of the presence of walls in the longitudinal direction, the first concern is about the earthquake response of the structure in the transverse direction.

I understand Building 221-H was constructed in the early 1950's. The design compressive strength of the concrete was 2500 psi. Intermediate grade reinforcement was specified in the contract documents.

The design vintage would suggest that the typical reinforcement details of the existing structure would not satisfy the current requirements based on the need for toughness. I also understand that some of the specified splice lengths do not satisfy current requirements for the reinforcement (f_y assumed to be 40,000 psi).

Despite the inferred shortcomings in desired reinforcement detail, the structure has particular attributes that are considered to be positive for earthquake resistance of reinforced concrete structures:

(a) High ratio of supporting-element cross-sectional area to supported floor area. (For example, at elev. 357', this ratio is approximately 4 %. In a typical low-rise building, that would suggest light or no damage in the event of a strong ground motion described by an effective peak acceleration of as much as 0.5 G. Admittedly, the structural configuration is not typical. But the experience is not irrelevant.)

(b) Low axial-load stress in the vertical elements suggesting the unlikelihood of brittle failure associated with crushing of concrete.

(c) Low longitudinal-reinforcement ratios in all elements suggesting the unlikelihood of brittle failures associated with shear.

From the desk of...

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Structural Engineer

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I understand that the lowest-translational-mode frequency of Section 6 in the transverse direction is 2 Hz (based on plain gross section) and that the limiting base-shear capacity in that direction has been estimated to be equal to approximately 10% of the building weight. For the given initial stiffness and the ground motion (identified by an effective peak acceleration not exceeding 0.3G), the estimated base shear-strength coefficient is not unacceptable.

Given the initial stiffness to mass ratio (indexed by the frequency of 2 Hz), the base shear strength, and the earthquake intensity stated above, the critical check would be determination of the maximum lateral displacement (drift) of the structure.

I see the combination of the controlling parameters for Building 221-H (mass-to-stiffness ratio, weight-to-strength ratio, and effective peak acceleration) to be favorable. The probability is very high that the integrity of the structure will not be adversely affected during the ground motion anticipated. To that end, it is important to establish the bounds of displacement response that the structure will sustain. Below, I would like to make a few general suggestions about how those studies may proceed. I can provide further detail if and as needed.

(1) Modal Spectral Response (Linear)

A linear modal analysis for drift based on a *modified* linear model can provide a satisfactory bound to the nonlinear displacement response of the structure. The steps to be followed are:

(a) Establish a design acceleration response spectrum at a damping factor of 2% of critical.

(b) Model the 2D structure (gross plain section) using 0.5E for Young's modulus, where $E=57{,}000\sqrt{f'_c}$.

(c) Calculate displacements at all joints on the basis of (a) and (b).

The critical issue is member distortion identified by the drift ratio obtained as the ratio of the relative drift of the joints to the length from joint to joint. In a typical structure, this would be the story drift ratio or the ratio of the relative displacement of two consecutive stories divided by the height of that story.

If the drift ratios calculated for the vertical elements exceed 2%, we need to examine the input/output carefully before we go any further with these analyses. If the calculated drift ratios are less, we need to do nonlinear analyses to develop confidence in the results through the parametric studies suggested below.

(2) Equivalent Nonlinear SDOF Oscillator Response

I understand the lowest translational mode of the analysis dominates the drift response and that the progressive limit analysis for lateral forces does not reveal a drastic change in the deflected shape of the structure. These conditions suggest that satisfactory drift estimates of the structure may be obtained from analyses of equivalent SDOF oscillators.

(a) Select a hysteresis routine (Takeda or bilinear).

(b) The "backbone curve" may be defined by fitting it to the static progressive collapse analysis already made. The initial slope should be set to obtain a k-to-m ratio resulting in the anticipated initial frequency. The final slope may be set at 5% of the slope of a line joining the origin to the assumed yield point (or the second breakpoint in the trilinear force-displacement curve).

(c) Use an equivalent viscous damping factor of 2%.

(d) Set the yield point to result in a desired F/W ratio (or base shear strength), where F is the yield force, and W is the oscillator mass (for the initial model the ratio would be 0.1 based on the lateral load analysis).

(e) Obtain solutions for maximum drift using different earthquakes and different F/W ratios to understand the sensitivity of maximum drift various parameters. Shape of the hysteresis may also be varied. The basic issue is the sensitivity of calculated drift to stiffness and to strength.

Note that the drifts at various joints in the structure will have to be projected from the calculated drift using the assumed mode shape of the structure.

(3) Nonlinear MDOF Dynamic Response

If needed, determine response drifts for selected ground motions using a nonlinear model for the structure.

(4) Checks for Toughness

Use static limit analyses to determine the maximum credible shear and bond stresses. Please note that the estimated drift will govern the limits of permissible unit strengths in shear and bond under cyclic loading.

From 15 to 20 March I am going to be at the Denver Marriott (downtown, tel 303-292-2472, fax 303-292-2472) attending the ACI meeting. If you need to contact me there, please feel free to do so.

I believe that a meeting will be more efficient if it is held after Greg and Tom have consolidated their position on the drift response of the structure. But if it becomes necessary to have a meeting in early April, I find the following dates convenient: Th 4 April, Sat 6 April, Tu 9 April

If those are impossible, I may be able to come in at a different date (other than 1-2 April when I shall be in Florida). For the time being, I am trying to protect my class days which are MWF.

Thank you again for your kindnesses during my visit.

Appendix B

Summary of Applicable Seismic Requirements from DOE Orders and Standards

Introduction

The seismic qualification of structures, systems and components is governed by an interrelated set of DOE Orders and Standards. These Orders and Standards deal with all accidents and natural phenomena hazards including wind, tornado, seismic, flood and lightning. This appendix provides an overview of the fundamental requirements of each of these Orders and Standards as they relate to seismic analysis of a safety class structure.

DOE Order 5480.28

DOE Order 5480.28 requires that structures, systems and components (SSCs) be designed and constructed to withstand the effects of natural phenomena hazards (NPH). If DOE criteria and standards are not available, national or industry consensus codes are deemed acceptable to meet the intent of the order. Order 5480.28 identifies the applicable DOE standards. DOE Standard 1020 provides reference to the acceptable industry and national consensus codes.

SSCs shall be reevaluated in accordance with the Order when:

The SSC was designed and constructed without adequate NPH design and construction standards,

There has been a significant change in understanding that results in an increase in the site NPH hazard, or

A significant physical change in the SSC has been caused by an addition, a modification, deterioration or a damaging NPH event.

The Order further stipulates that a review of the state-of-the-art of NPH assessment methodology and of site specific information shall be conducted at least every ten years. The assessment of SSCs shall utilize a graded approach. Each SSC will be assigned a Performance Category (0 through 4) on the basis of its safety, mission, and cost significance that will satisfy the defined facility probabilistic Performance Goals. The canyon buildings have been assigned Performance Category 3 per these requirements.

Performance Categorization (DOE Standards 1027 and 1021)

DOE Standard 1027 provides guidance on several of the requirements in DOE Order 5480.23. This standard establishes the threshold quantities of hazardous materials which, if exceeded, would mandate development of a Safety Analysis Report (SAR), discusses the SAR upgrade plan and schedule that must be submitted, and gives guidance on the use of graded approach and accident/hazard analysis techniques for compliance with Order 5480.23. Additionally, Standard 1027 provides methodology for hazard categorization that is essential for determining NPH Performance Category. Based on the quantity of materials they contain, the canyon facilities have been assigned Hazard Category 2 per these requirements.

DOE Standard 1021 provides guidelines for the categorization of SSCs for evaluation of NPH events. The process is one of assigning a Performance Category for each SSC based on the facility Hazard Category from DOE-STD-1027 and the functional classification of each SSC from safety analyses. As mentioned above, the canyon buildings have been assigned Performance Category 3.

Seismic Design Criteria (DOE Standard 1020)

DOE Standard 1020 describes the requirements in each of the Performance Categories (PC) for the design or evaluation of new and existing SSCs for NPH events. For seismic evaluation, the Standard provides guidance in four areas:

(1) selection of the earthquake loading,
(2) evaluation of the earthquake response (load on the structure),
(3) specification of structural seismic capacity (acceptance criteria), and
(4) structure ductile detailing requirements.

Seismic loading is defined in terms of a site-specific design response spectrum, called the design or evaluation basis earthquake (DBE/EBE) and probabilistic seismic hazard curves. For each Performance Category, a mean annual probability of exceedance or return period for the EBE is specified. At this return period the peak ground acceleration may be determined from probabilistic seismic hazard curves (peak ground acceleration vs. annual probability of exceedance). For PC3 (canyon buildings) the exceedance probability is 5×10^{-4} or a 2,000 year return period. The seismic ground motion to be used for design or evaluation is defined by a median response spectrum scaled to the peak ground acceleration. The design response spectrum and probabilistic seismic hazard curve are developed in accordance with DOE Standards 1022, 1023 and 1024.

PC1 and 2 structures are evaluated in accordance with the seismic provisions of the Uniform Building Code (UBC) [B-1]. For PC3 and 4 facilities the structural seismic response must be determined by a dynamic analysis. The dynamic analysis approach should comply with the seismic analysis provisions of ASCE 4 [B-2]. Capacities for PC3 concrete structures are determined in accordance with ACI 318 [B-3]. For all Performance Categories limited inelastic behavior is allowed if justified by design details.

The structure is adequate when:

Structural capacity ≥ total demand.

Story drifts do not exceed 1% of the story height. However, these drift limits may be exceeded when acceptable performance of the structural elements can be demonstrated at greater drift.

If the existing facility can be shown to meet the design and evaluation criteria presented and good detailing practice has been employed, then the facility is judged adequate for its potential seismic hazards. In accordance with Standard 1020, if the facility does not meet the seismic evaluation criteria, several alternatives are allowed :

If an existing structure is close to meeting the criteria, an increase in the annual risk due to seismic can be permitted, allowing the evaluation to be performed at twice the recommended hazard exceedance probability (half the return frequency).

Strengthen the structure such that the capacity is adequate to meet demand.

It may be possible to conduct the seismic evaluation in a more rigorous manner using more representative input such that the structure may be shown to be adequate. Alternatively, a probabilistic assessment may be undertaken in order to demonstrate that the performance goals can be met.

Determination of Seismic Hazard (DOE Standards 1022, 1023 and 1024)

The studies of site characteristics required to be performed to characterize the seismic hazard are defined in DOE Standard 1022. This site specific characterization provides the necessary input to implement DOE Standard 1023 for the development of design response spectra. DOE Standard 1024 provides guidance for the use of seismic hazard curves developed by Lawrence Livermore National Laboratory (LLNL) and the Electric Power Research Institute (EPRI). The following summarizes each document.

DOE Standard 1022

Guidance regarding the site specific characterization of seismic hazard is provided in Standard 1022. The important geologic factors to be considered include:

determining the existence of Quaternary faults within 25 miles radius of the site,

determining whether any magnitude six earthquake is associated with an active Quaternary fault within a 200 mile radius of the site,

identifying all faults with length greater than 1000 feet within 5 miles of the site and determining whether there is evidence of any Quaternary movement on such faults, and

determining potential for site-specific amplification of vibratory ground motion.

Both deterministic and probabilistic methodologies for hazard evaluation are required. For probabilistic hazard analyses, sites may use a combined EPRI and LLNL result, if applicable, or complete a new estimate using site-specific data including definition of source zones, earthquake recurrence rates and ground motion attenuation.

DOE Standard 1023

DOE Standard 1023 defines the requirements for development of the site specific response spectrum. This standard requires:

A probabilistic seismic hazard assessment (PSHA) must be conducted for the site if existing PSHA is greater than 10 years old.

A target DBE response spectrum for the site is defined by the mean uniform hazard response spectrum (UHS).

The appropriateness of the site DBE response spectrum is determined by comparing median spectral shapes that shall be derived from earthquake source parameters derived from deaggregated PSHA at two specific frequencies to the mean UHS.

The site DBE response spectrum will consider historical earthquakes with magnitude > 6 that may have affected the site.

Probabilistic assessment of ground failure should be applied if necessary (fault rupture hazard).

DOE Standard 1024

DOE Standard 1024 was developed for Eastern United States (EUS) DOE sites to address variability in the probabilistic hazard investigations conducted by EPRI and LLNL for EUS nuclear power plants and DOE facilities. In particular, Standard 1024 describes how to combine the LLNL and EPRI hazard results and gives specific peak ground acceleration (PGA) values at assigned probability of exceedances for SRS.

Applicable DOE Orders

5480.23 Nuclear Safety Analysis Reports

5480.28 Natural Phenomena Hazards Mitigation

Applicable DOE Standards

1020-94 Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities

1021-93 Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components

1022-94 Natural Phenomena Hazards Site Characterization Criteria

1023-95 Natural Phenomena Hazards Assessment Critéria

1024-92 Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites

1027-92 Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23

References

B-1. Uniform Building Code, International Conference of Building Officials

B-2. American Society of Civil Engineers, ASCE 4-86, Seismic Analysis of Safety Related Nuclear Structures, September 1986

B-3. American Concrete Institute, ACI-318, Building Code Requirements for Structural Concrete

Appendix C

Continued Applicability of the IMNM EIS

The National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to develop Environmental Impact Statements (EIS) to analyze the impacts of an agency's action. An EIS provides decision-makers and the public with information to make reasonable choices among alternatives based on an analysis of the environmental impacts associated with an agency's proposed action.

Criteria

As identified in DOE's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements", an EIS must deal with the environmental impacts that will not necessarily occur under a proposed action but which are reasonably foreseeable. The term "reasonably foreseeable" has no precise definition. Its interpretation is guided by the purpose of a NEPA review, which is to inform the agency and the public in making reasonable choices among the alternatives. Consequently, the accident impacts section of an EIS has no clearly defined evaluation criterion. However, an EIS must illustrate the consequences and the probability of occurrence. Acceptable "reasonably foreseeable" impacts include those that may have very large or catastrophic consequences, provided their probability of occurrence is low, and the impact analysis is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason. Thus, a high-consequence event would not necessarily have "significant impacts" (in the sense of NEPA) if its probability of occurrence is very low. Therefore, a reasonable evaluation criterion is risk (i.e., the product of consequence times frequency).

Evaluation

The Record of Decision for the Interim Management of Nuclear Materials EIS states:

> ". . . certain management alternatives are expected to result in lower environmental impacts than others. However, a single alternative was rarely estimated to have lower impacts for all environmental factors evaluated by DOE. For example, an alternative might be expected to result in lower releases of hazardous pollutants to air or water than the other alternatives, but might generate slightly higher amounts of radioactive waste. DOE reviewed the environmental impacts estimated for the alternatives evaluated for each type of nuclear material and identified the following [i.e., in ROD Section VII, Environmentally Preferable Alternatives] as the environmentally preferable for each. The health effects from any of the alternatives are all low and well within regulatory limits."

It is important to note that many different estimated environmental impacts, in addition to accident impact analysis, were evaluated in making the final decision. Furthermore, Section VII, Environmentally Preferable Alternatives, of the ROD indicates that dominant factors considered in choosing each alternative were impacts associated with routine facility operation and not the estimated accident impacts.

The EIS has the following discussion of health effects in Section 2.4.1:

> "As indicated in Tables 2-2 through 2-12, the radiological health effects from normal operations (including transportation activities) would vary among the alternatives, but all would result in less than one additional latent cancer fatality in the population surrounding the SRS and in the worker population over the 10-year period. The health effects from potential facility or transportation accidents involving the alternatives range from less than 1 to 38 additional latent cancer fatalities in the offsite population should the worst-consequence accident occur. Alternatives involving processing operations in the chemical separations facilities and the

Defense Waste Processing Facility would have higher potential accident consequences (in the form of additional latent cancer fatalities in the offsite population) than alternatives involving no action or improving storage, because processing operations in the chemical separations facilities and DWPF could experience accidents with higher potential consequences than facilities used simply to store radioactive material (i.e., vaults or basins)."

There is no additional significant discussion of risk in the EIS. Based on the above quote, it is apparent that the base conclusions in the EIS for accidents rely on the calculated additional latent cancer fatalities being in the range of 1 to 38.

Quantitative Reassessment of Seismic Components of EIS Risk

Calculations have been performed to reassess the estimates for the latent cancer fatalities (LCFs) listed in the IMNM EIS related to seismic events affecting the canyons using: (1) the new information on seismic event frequencies (i.e., the frequency of an evaluation basis earthquake has increased from 2.0E-4/year to 5.0E-4/year) and (2) revised estimates for the inventories that will be in the facilities for each of the proposed activities covered in the EIS. The LCF value calculations were performed in a manner similar to the EIS methodology. No new codes were introduced to do the calculations.

The revised estimates for the number of LCFs are lower than the corresponding values in the EIS, despite the higher postulated frequency of seismic events affecting the canyon facilities. The primary reason for the lower LCF values is that the currently planned inventories are much lower than the maximum facility inventories used for the EIS. The EIS is based on pre-existing authorization basis documents. These pre-existing documents were largely based on analyses, performed prior to the end the Cold War, which assumed the facilities would be operating at full capacity and operating on relatively fresh irradiated reactor fuel. The planned stabilization operations involve much lower inventories. In many instances, these operations involve existing materials, where fission products have previously been removed. Where the planned operations do involve irradiated reactor fuel, the fuel is several years old and some fission products accounted for in the original analyses have decayed away.

Each of the over eighty sequences in the EIS associated with seismic events was reassessed. These calculations used a facility inventory input which bounds the inventories expected during completion of material stabilization operations as described in the DOE 94-1 Implementation Plan and planned post-Cassini Pu-238 processing (including receipt of remaining returns). Risk was determined by combining the new frequencies for each sequence with the projected source terms (inventories). Tables were constructed calculating the new latent cancer point estimate of risk per year, and determining the percentage increase or decrease in risk for each sequence from that previously reported in the EIS. For example, the Pu-242 point estimate of risk for the no action option which was 4E-8 as a point estimate per year of latent cancer fatality was recalculated as 2E-8. This process was repeated for each sequence to arrive at the conclusion that the overall risk of latent cancer fatality remains within the original 1-38 range.

The new calculations represent only the relevant portions of Tables E.4 through E.12 of the EIS (those related to seismic events affecting the canyons). Other types of events and other facilities are also covered in Tables E.4 thorough E.12. These other types of events and other facilities dominate the risks, not the canyon seismic events. The seismic component represents only about 20% of the overall risk projections. Therefore, the risk decreases from this reassessment for seismic events have a negligible effect on the overall relative risks for the various alternatives.

Additional Margins in Risk Estimates Through Methodology Improvements

The EIS dose estimates were prepared with the AXAIR89Q computer code. This dose model was developed to perform dose calculations in compliance with the U. S. Nuclear Regulatory Guide 1.145, and specific to the Savannah River Site meteorology. However, the dispersion model is limited and does not account for phenomenology that accompanies the downwind transport of radioactive species from a nuclear facility.

The MACCS computer code, developed by Sandia National Laboratories (SNL) for the USNRC and the Department of Energy, has been used in the DOE Complex for safety analyses of nuclear facilities for approximately the past three years. The MACCS dispersion model is a more realistic tool for calculating bounding doses to offsite individuals. In particular, deposition, resuspension, source term energetics and duration, and plume meander models in MACCS represent updated or completely new capabilities relative to the code used in the EIS. Comparisons performed at Savannah River indicate factors of two to nearly ten reduction in the (Maximum Exposed Offsite Individual) MEI dose calculated by MACCS relative to AXAIR89Q. For purposes of making a more direct comparison, MACCS was not used in the reassessment described above.

Appendix D

Best Estimate of Risk Associated With Collapse of the SRS Canyon Buildings

The present EBE, as stated earlier in this document, has a return period of 2,000 years. The total seismic analysis is not yet complete, but WSRC expects that the F and H Canyons will meet the no-collapse criteria for the 2000-year earthquake. Since calculations to demonstrate the meeting of the no-collapse criteria are not yet complete, an analysis has been undertaken which looks at the consequences, on a best estimate basis, for a situation where both canyons have collapsed. For the purposes of this analysis, it was conservatively assumed that the earthquake which causes the collapse has a return period of 1,000 years.

After a postulated facility collapse, nuclear material inventories would pose hazards to onsite workers and the offsite general public. Depending on the accident, a spectrum of scenarios and associated consequences may result. Material may be released by spillage which may be followed by a fire and/or an explosion. One or more processing tanks could be involved or ultimately compromised. This wide variety of scenarios was considered using logic models typically applied for accident sequence analysis in DOE facilities.

A logic model was developed which had a number of possible sequences and with a variety of frequencies of occurrence and consequences. Thus, the calculated risk is based on a combination of frequency related assumptions and consequence related assumptions.

The major accident sequence assumptions are:

- Connections between tanks are severed and explosions do not propagate.
- The HB-Line Vault releases 10% of its powder and FB-Line releases 50%.
- Explosion involves the largest single tank in each facility (total of 4).
- In sections which contain flammable liquid, 5% of the total liquid inventory is assumed to be flammable.
- All Airborne Release Fraction (ARF) and Respirable Fraction (RF) values used were median values, except for Fire & Explosion where a median value was not given and, therefore, a bounding value was used.
- All Leak Path Factors (LPF) were assumed to be 1.0.

The frequency related assumptions are:

- Since the canyon "trough" is estimated to remain, electrical jumpers will not be powered and lying on the floor of the cells. Thus, ignition sources for fires and explosions are assumed to be unlikely to occur (probability of occurrence of 0.1).
- If a fire occurs, the probability of ignition for an explosion is assumed to be 0.5, even though the explosion generally cannot occur for a number of days.
- The frequency of an earthquake that will collapse the facility is 0.001/year (a 1,000 year return period).

Using the above assumptions, the resulting median 50-year cumulative dose to the maximum exposed offsite individual (MEI), given occurrence of the canyon collapse, is determined to be 1.8 rem. Using the conservative frequency assumption for the EBE-induced canyon collapse of 1.0×10^{-3} per year, the point estimate risk to the MEI is 1.8 mrem/year. As shown in Table D.1, this dose value is less than 1% of the average dose to an individual in the U.S. from natural sources (NCRP No. 93). This calculation is intended to be a best estimate, not a bounding value, for the risk from a collapsed facility.

Safety Goal Compliance

Quantitative guidance on severe accident safety goals for U.S. nuclear power plant operation was promulgated in the Federal Register in 51FR28044 (1986). The technical basis is discussed in NRC Report NUREG-0880 (1983). In Secretary of Energy Notice SEN-35-91 (September 9, 1991), the Secretary stated explicit DOE nuclear safety policy applicable to all DOE facilities (excluding naval reactors). These criteria are in substance identical to the NRC quantitative safety goals.

Two goals or targets for risk to the general public from DOE nuclear facility operation were stated in SEN-35-91:

Individual Prompt Risk:

The risk to an average individual in the vicinity of a DOE nuclear facility for prompt fatalities that might result from accidents should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatalities resulting from other accidents to which members of the population are generally exposed. For evaluation purposes, individuals are assumed to be located within one mile of the site boundary.

Individual Latent Risk:

The risk to the population in the area of a DOE facility for cancer fatalities that might result from operations should not exceed one-tenth of one percent (0.1%) of the sum of all cancer fatality risks resulting from all other causes. For evaluation purposes, individuals are assumed to be located with ten miles of the site boundary.

Quantitatively, the goals are typically related to accidental and latent fatality rates in the U.S. population as a whole. These are:

DOE Target (Goal) for Prompt Risk
= 0.1% x Average U.S. Risk = 5.0×10^{-7} per individual per year, and

DOE Target (Goal) for Latent Risk
= 0.1% x Average U.S. Risk = 2.0×10^{-6} per individual per year.

Again applying a frequency of 1×10^{-3} per year, the individual prompt and latent risk due to the best-estimate source term, are 0 and 9.0×10^{-7} per individual per year, respectively.

Table D.1 Dose and Risk Consequence From Postulated Canyon Collapse

Consequence / Criterion	Dose / Risk
1. MEI Dose	1.8 rem (median meteorology)
2. MEI Risk	1.8 mrem/year (1×10^{-3} per year frequency)
3. U.S. Average Dose From Natural Sources	300 mrem/year
4. DOE Safety Goal - Prompt	5.0×10^{-7} per individual per year
5. Individual Prompt Risk to Offsite from Canyon Collapse	0
6. DOE Safety Goal - Latent	2.0×10^{-6} per individual per year
7. Individual Latent Risk to Offsite from Canyon Collapse	9.0×10^{-7} per individual per year

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