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9.0. PEER-2004 REVIEW

This chapter describes the regulatory basis for the conduct of peer reviews and summarizes relevant peer reviews performed at the Waste Isolation Pilot Plant (WIPP). Key elements of the U.S. Department of Energy (DOE) Carlsbad Field Office's (CBFO's) peer review program (for example, the review process, reports, selection criteria, and training for review panel members) are discussed. Two categories of peer reviews are reported in this chapter: (1) those conducted after the promulgation of Title 40 of the Code of Federal Regulations (CFR) Part 194 (U.S. Environmental Protection Agency [EPA] 1996a); and (2) those conducted earlier.

Seven peer reviews were initiated subsequent to the promulgation of 40 CFR Part 194 and prior to submission of the Compliance Certification Application (CCA) in 1996. Per the criteria of 40 CFR § 194.27, they were conducted in a manner compatible with NUREG-1297 (Altman, et al. 1988). The subjects of these reviews included: conceptual models; waste characterization analysis; engineered alternatives cost/benefit study (EACBS) ; engineered systems data qualification; waste form and disposal room data qualification; natural barriers data qualification; and passive institutional controls. The conceptual model peer review group published three supplementary reports in 1996 and 1997 after the submission of the CCA. Two additional peer reviews related to conceptual models were completed in 2003 prior to submission of the first Compliance Recertification Application (CRA-2004), and are described in Section 9.3.1. These reviews are summarized in the following sections:

- 9.3.1 – Conceptual Models Peer Review
- 9.3.2 – Waste Characterization Analysis Peer Review
- 9.3.3 – Engineered Alternatives Cost/Benefit Study Peer Review
- 9.3.4 – Engineered Systems Data Qualification Peer Review
- 9.3.5 – Natural Barriers Data Qualification Peer Review
- 9.3.6 – Waste Form and Disposal Room Data Qualification Peer Review
- 9.3.7 – Passive Institutional Controls Peer Review

The applicable peer review plans, complete peer review reports, and selected supporting documentation for peer reviews completed before submission of the CCA in 1996 were provided in CCA Appendix PEER. The plans, reports, and supporting documentation for the peer reviews performed after the submission of the)CCA are provided in Appendix PEER-2004. This chapter also presents the DOE responses to the findings and recommendations of the peer reviews. Additional documentation is available in project record packages in the CBFO Records Holding Facility located in Carlsbad, New Mexico.

Peer reviews that occurred prior to the promulgation of 40 CFR Part 194 were not necessarily conducted in accordance with NUREG-1297 guidelines. Therefore, candidate reviews were evaluated against specific criteria to determine whether they were appropriate for inclusion in this application. The selected historical reviews were summarized in the following sections of the CCA Chapter 9:

- 9.4.1 – National Academy of Sciences WIPP Panel Reviews (12 reports)
- 9.4.2 – Performance Assessment Peer Review Panel
- 9.4.3 – Shaft Seal Design Independent Review
- 9.4.4 – Engineered Alternatives Task Force Report Peer Review
- 9.4.5 – Blue Ribbon Panel Peer Review
- 9.4.6 – Advisory Committee on Nuclear Facility Safety Review (two reports)
- 9.4.7 – Performance Assessment Review Team (PART)
- 9.4.8 – INTRAVAL
- 9.4.9 – WIPP Conceptual Model Uncertainty Group Review
- 9.4.10 – Environmental Evaluation Group Reviews (15 reports)
- 9.4.11 – Fracture Expert Group Review
- 9.4.12 – Fanghänel Review
- 9.4.13 – Independent Technical Review of the Bin and Alcove Test Programs
- 9.4.14 – Performance Assessment (PA) Reviews
- 9.4.15 – Technical Support Group Reviews (two reports)
- 9.4.16 – National Environmental Policy Act Reviews

The full reports from these reviews and selected supporting material were provided in CCA Appendix PEER.

Summaries of additional reviews performed by oversight organizations since the submission of CCA are included in the following sections:

- 9.4.1.13 to 9.4.1.15 – National Academy of Sciences WIPP Panel Reviews (three reports),
- 9.4.10.16 to 9.4.10.26 – Environmental Evaluation Group (EEG) Reviews (11 reports),

- 9.4.17 – International Atomic Energy Agency (IAEA) and Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) Joint Report (one report),
- 9.4.18 – GEOTRAP (An NEA/OECD project), and
- 9.4.19 – Institute for Regulatory Science (RSI) of the American Society of Mechanical Engineers (ASME) (two reports).

These reviews are in addition to those required by 40 CFR Part 194.27(a), do not meet the requirements of NUREG-1297, and are not used directly by the DOE for the analyses in the CRA. The full reports from these reviews and selected supporting materials are provided in Appendix PEER-2004.

9.1 Regulatory Requirements

The certification criteria in 40 CFR Part 194 prescribes the use of peer reviews to support certain areas of the compliance evaluation. Compliance criteria in 40 CFR § 194.27 state that peer review at the WIPP be performed for several specific aspects of the program and that they be performed in a manner compatible with NUREG-1297. NUREG-1297 provides guidance on the definition of peer reviews, the areas for which a peer review is appropriate, the acceptability of peers, and the conduct and documentation of peer reviews. 40 CFR Part 194 states that "The specific requirements in NUREG-1297 that discuss for which activities peer review should be conducted do not apply, nor do they supersede the requirements of the final rule." (61 Federal Register [FR] 5228) Specific sections of 40 CFR Part 194 and NUREG-1297 provide the regulatory basis for this chapter.

The certification criteria state that any application for certification shall include documentation for the following peer reviews that are to be conducted: conceptual models used in the PA; waste characterization analysis; and engineered barrier evaluation (40 CFR § 194.27[a]). Section 194.27(b) states that these peer reviews, if conducted subsequent to the promulgation of 40 CFR Part 194, should be conducted in a manner that is compatible with NUREG-1297. Section 194.27(c)(2) also requires this application to include documentation of any peer review processes conducted in addition to those of 40 CFR § 194.27(a).

NUREG-1297 defines peer review as "a documented, critical review performed by peers who are independent of the work being reviewed." NUREG-1297 also states that a "peer review is an in-depth critique of the assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed, and of conclusions drawn from the original work."

The 40 CFR Part 194 Background Information Document (EPA 1996b) states that peer reviews can be used as part of "a comprehensive quality assurance program" to give "confidence that work completed, underway, or planned was, is, or will be properly performed." The Background Information Document also notes that "additional peer review is also necessary to establish the validity of procedures, methods, or interpretations which may not be addressed by a quality assurance (QA) program . . . ASME-NQA-3-1989 . . . includes peer review among those activities affecting quality associated with the collection of scientific and technical information, when other established methods cannot be used to establish the adequacy of information."

NUREG-1297 states that for a repository,

> peer reviews should be used as a management tool to achieve confidence in the validity of certain technical and programmatic judgments. The intent of a peer review is to pass judgment on the technical adequacy of the work or data submitted for review, to identify aspects of the work on which technical consensus exists, to identify aspects on which technical consensus does not exist, and to identify aspects of the reviewed work which the reviewers believe to be incorrect or which need amplification. A peer review provides assurance in cases where scientific uncertainties and ambiguities exist but in which technical and programmatic judgments and decisions still must be made.

9.2 Peer Review Process

NUREG-1297 suggests that procedures be developed to "implement the NUREG-1297 guidance" and to "provide methods for initiating a peer review." These procedures, for any given peer review, "should require a planning document that describes the work to be reviewed, the size and spectrum of the peer review group, and the suggested method and schedule to arrive at a peer review report."

WIPP-specific plans and procedures ensure that peer reviews performed subsequent to promulgation of 40 CFR Part 194 were conducted in accordance with the criteria of 40 CFR Part 194 and compatible with NUREG-1297. The most pertinent of the plans and procedures are discussed briefly below.

A Peer Review Management Plan (PRMP) (DOE 1996b) was developed and approved by the CAO to describe the management processes used to control the planning, implementation, and documentation of these reviews. The PRMP defines the management approach, resources, schedule, and technical requirements for using peer reviews to confirm and/or verify the adequacy of data and/or information utilized to support the WIPP application.

CAO Team Procedure (TP) 10.5, Peer Review (DOE 1996c) has been replaced by CBFO Management Procedure (MP) 10.5 (DOE/CBFO 2003). TP 10.5 was used to guide the peer reviews performed prior to submission of the CCA and the three supplementary conceptual model peer reviews performed after CCA in October 1996 to April 1997. MP 10.5 guided the peer reviews performed in 2002-2003. Both procedures define the responsibilities, requirements, and methodologies incorporated in the performance of peer reviews conducted by the CAO (for CCA) and the CBFO (for CRA-2004) pursuant to the criteria of 40 CFR § 194.27. The procedures provided the criteria for determining the size and composition of the review panel and for selecting individual peer review panel members, and outline the orientation and training to be provided for the panelists. The procedures also describe the actual peer review process, provide criteria for development of peer review plans and report preparation, and define the responsibilities of individuals involved in the process. Both TP 10.5 and MP 10.5 were developed in accordance with, and to implement, the guidance in NUREG-1297, "Peer Review for High-Level Nuclear Waste Repositories."

Specific peer review plans were developed for each peer review at the WIPP. These plans documented the planning process for the peer reviews and were prepared and approved prior to performing the particular review (see Section 9.2.1).

As discussed more completely in Chapter 5.0, the Quality Assurance Program Document, Rev.5 (QAPD) (DOE 2003) establishes the minimum requirements for the WIPP QA program. It provides guidance for development and implementation of QA programs for all aspects of the WIPP project. In particular, the QAPD provides general requirements for training, document control, and QA records management.

9.2.1 Peer Review Plan

MP 10.5 requires that the Peer Review Manager ensure that a peer review plan is prepared and approved prior to the performance of each peer review. Specific plans are approved by the CBFO.

The plan documents the planning of the peer review. It provides the scope of the peer review, a description of the work to be reviewed, the intended use of the work, and methods for conducting peer reviews.

40 CFR § 194.27(b) specifies that peer reviews performed subsequent to the promulgation of 40 CFR Part 194 be conducted in a manner compatible with NUREG-1297. NUREG-1297 states that

> The peer review process may vary from case to case, and should be determined by the chairperson of the peer review group, consistent with the guidance provided in this GTP (Generic Technical Position). In meetings and/or correspondence, the peer review group should evaluate and report on: (a) validity of assumptions; (b) alternate interpretations; (c) uncertainty of results and consequences if wrong; (d) appropriateness and limitations of methodology and procedures; (e) adequacy of application; (f) accuracy of calculations; (g) validity of conclusions; (h) adequacy of requirements and criteria. Furthermore, full and frank discussions between the peer reviewers and the performers of the work are encouraged.

The WIPP peer review process consists of an in-depth analysis and evaluation of documented assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed, and of conclusions drawn in the original work. MP 10.5 specifically incorporates the above NUREG-1297 requirements into the WIPP peer review process.

9.2.2 Size and Composition of Peer Review Panels

NUREG-1297 states that

> The number of peers comprising a peer group should vary with the complexity of the work to be reviewed, its importance to establishing that safety or waste isolation performance goals are met, the number of technical disciplines involved, the degree to which uncertainties in the data or technical approach exist, and the extent to which differing viewpoints are strongly held within the applicable technical and scientific community concerning the issues under review. The collective technical expertise and qualifications of peer group members should span the technical issues and areas involved in the work to be reviewed, including any differing bodies of scientific thought. Technical areas more central to the work to be reviewed should receive proportionally more representation on the peer review group.

The NUREG-1297 guidance also states that

> The peer review group should represent major schools of scientific thought. The potential for technical or organizational partiality should be minimized by selecting peers to provide a balanced review group.

The size and composition of peer review panels established after the promulgation 40 CFR Part 194 were determined by a selection committee consisting of the Peer Review Manager and two members selected by the Peer Review Manager.

Technical requirements for each peer review panel were established by the Peer Review Manager and provided to the selection committee, which then developed a list of potentially qualified personnel. Once a panel member was officially selected and had agreed to serve, the selection committee members documented the rationale for the selection of that peer review panel member on a "Peer Review Panel Selection, Size and Composition Justification/Decision Form," which is maintained as a QA record.

The number of members selected for a particular panel depended on the amount and complexity of the work to be reviewed, its importance for establishing that safety or waste isolation performance goals are met, the number of technical disciplines involved, the degree to which uncertainties in the data or technical approach exist, and the extent to which differing viewpoints were strongly held within the applicable technical and scientific community concerning the issues under review. The panel members were selected based on their collective technical expertise and qualifications so that they spanned the technical issues and areas involved in the work to be reviewed, including differing bodies of scientific thought. The technical areas more central to the work under review received proportionally more representation on the peer review panel. To the extent practical, the panels represented the major schools of scientific thought pertinent to the subject being reviewed. The selection committee strived to eliminate the potential for technical or organizational partiality by selecting peer reviewers that provided a balanced panel.

9.2.3 Technical Qualifications of Panel Members

NUREG-1297 states that

> The technical qualifications of the peer reviewers, in their review areas, should be at least equivalent to that needed for the original work under review and should be the primary consideration in the selection of peer reviewers. Each peer reviewer should have recognized and verifiable technical credentials in the technical area he or she has been selected to cover. The technical qualifications of each peer, and hence of the peer review group as a whole, should relate to the importance of the subject matter to be reviewed.

MP 10.5 specifies that the acceptability of any peer review panel member be based on the above NUREG-1297 requirements. The Peer Review Manager is required to ensure that education and pertinent experience information is verified and documented prior to the start of the peer review process. This documentation is also maintained as QA records.

9.2.4 Independence of Panel Members

NUREG-1297 states that

> Members of the peer review group should be independent of the original work to be reviewed. Independence in this case means that the peer, a) was not involved as a participant, supervisor, technical reviewer or advisor in the work being reviewed, and b) to the extent practical, has sufficient freedom from funding considerations to assure the work is impartially reviewed.
>
> Because of DOE's pervasive effort in the waste management area, the lack or unavailability of other technical expertise in certain areas, and the possibility of reducing the technical qualifications of the reviewers in order that total independence is maintained, it may not be possible to exclude all DOE or DOE contractor personnel from participating in a peer review. In those cases where total independence cannot be met, a documented rationale as to why someone of equivalent technical qualifications and greater independence was not selected should be placed in the peer review report.

NUREG-1297 allows both the work under review and the peer review of that work to be funded by DOE. It also provides the caveat that the

> …independence criteria is not meant to exclude eminent scientists or engineers upon whose earlier work certain of the work under review is based so long as a general scientific consensus has been reached regarding the validity of their earlier work.

MP 10.5 provides that the above NUREG-1297 requirements be used in selecting panel members. Each peer review panel member is required to document his or her independence. These documents are reviewed and approved by the Peer Review Manager and maintained as QA records.

9.2.5 Training of Peer Review Panel Members

MP 10.5 requires that the Peer Review Manager ensure all peer review panel members receive adequate training prior to beginning a peer review. Training consists of reading assignments and, if deemed necessary by the Peer Review Manager or the Peer Review Panel Coordinator, briefings and classroom training. Assigned reading includes 40 CFR Parts 191 (EPA 1993) and 194, NUREG-1297, the CBFO QAPD, MP 10.5, and the applicable Peer Review Plans.

MP 10.5 further requires that all panel members receive an orientation prior to the start of the peer review process. The orientation includes information on the peer review process, administrative requirements, the applicable Peer Review Plan, a summary of the technical subject matter, and an overview of MP 10.5. Panel member training and orientation are documented and this documentation is maintained as a QA record.

9.2.6 Peer Review Panel Report

NUREG-1297 states that

> A written report documenting the results of the peer review should be issued. It is usually prepared under the direction of the chairperson of the peer review group, and is signed by each member individually. It should clearly state the work or issue that was peer reviewed and the conclusions reached by the peer review process . . . The report should include individual

> statements by peer review group members reflecting dissenting views or additional comments, as appropriate. The peer review report should contain a listing of the reviewers and any acceptability information (i.e., technical qualifications and independence) for each member of the peer group, including potential technical and/or organizational partiality.

MP 10.5 requires that a peer review report be prepared for each peer review. Each panel member is required to sign and date the report. The report describes the work or issue that was reviewed as well as the conclusions reached by the panel, and provides individual statements by the members reflecting dissenting views or additional comments, as appropriate. Finally, the report lists the peer review panel members and provides technical qualifications and independence information for each member.

9.2.7 Quality Assurance Records Management

NUREG-1297 specifies that written "…minutes should be prepared of meetings, deliberations, and activities of the peer review process."

MP 10.5 requires that written minutes, including graphic or calculated materials used in panel meetings, be prepared for meetings, deliberations, daily caucuses, and other activities. These written minutes are maintained as QA records. MP 10.5 also requires that a QA records management system be developed and implemented to ensure that peer review documents are identified, assembled, and transferred on a timely basis and in an orderly manner to the appropriate records center.

9.2.8 Quality Assurance Oversight

Section V of NUREG-1297 states that "As a minimum, the QA organization should provide surveillance of the peer review process to ensure that the procedures conform to the guidance of this GTP and that they are followed by the peer review group."

The QAPD establishes requirements for implementing the QA program for the WIPP peer review process. The QAPD requires that assessments be conducted to ensure that all aspects of the peer review conform to the guidance of NUREG-1297. Additional details regarding the WIPP QA program are provided in Chapter 5.0.

9.3 Peer Reviews Conducted After Promulgation of 40 CFR Part 194

Seven peer reviews were performed by the WIPP project prior to submitting the CCA in 1996 to address issues deemed necessary by the DOE. These peer reviews included reviews of conceptual models, waste characterization analysis, and an evaluation of the benefits and detriments of potential engineered barriers and alternatives as stated in 40 CFR § 194.27(a); data reviews of engineered systems, waste form and disposal room, and natural barriers as stated in 40 CFR § 194.22(b); and a passive institutional controls review. These peer reviews were conducted subsequent to the promulgation of 40 CFR Part 194 and were conducted in a manner consistent with the NUREG-1297 guidance, as implemented by TP 10.5 and the QAPD.

Specifically, the following peer reviews have been conducted:

- evaluation of the adequacy and reasonableness of the WIPP conceptual models;
- a review of the adequacy and completeness of the waste characterization analysis;
- an assessment of the validity of the assumptions and approach used to select or reject engineered alternatives, as delineated in the EACBS (DOE 1995b) for the WIPP;
- a data qualification review of parameters used to describe engineered systems;
- a data qualification of parameters used to describe natural barriers;
- a data qualification of parameters used to describe the waste form and disposal room; and
- a determination of whether the passive institutional controls have a reasonable expectation of meeting their intended purpose.

The conceptual model peer review group published three supplementary reports in 1996 and 1997 after the DOE submitted the CCA. These were also conducted in a manner consistent with the NUREG-1297 guidance, as implemented by TP 10.5 and the QAPD.

Two additional peer reviews related to conceptual models were completed in 2003. These were conducted in a manner consistent with the NUREG-1297 guidance, as implemented by CBFO's MP 10.5 and the QAPD. These five post-CCA peer review reports are summarized in Section 9.3.1 and the full reports are included in Appendix PEER-2004.

These reviews are discussed, and the WIPP project response to the peer review panel's comments is provided in the following sections. The general process used by the DOE to plan and conduct the seven peer reviews is described in Section 9.2. The complete reports of peer reviews performed before submitting the CCA were included in CCA Appendix PEER, and those performed after submitting the CCA are provided in Appendix PEER-2004. The reports were all consensus documents signed by all members of the specific panel involved: that is, there were no dissenting views on any of the final reports for the seven subject reviews.

9.3.1 Conceptual Models Peer Review

40 CFR § 194.23(a)(3)(v) specifies that this application include documentation that the conceptual models have undergone peer review consistent with 40 CFR § 194.27. A Conceptual Model Peer Review (CMPR) Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of CAO's TP 10.5 (Replaced by MP 10.5 for CRA-2004). The CMPR Plan describes the peer review process used to ensure that the conceptual models used in the WIPP PA reasonably represent possible future states of the disposal system.

In accordance with the provisions of TP 10.5, a peer review panel was selected and organized in April 1996. The six-member panel was composed of the following individuals:

- Charles R. Wilson (Chairman), Private Consultant;

- Florie A. Caporuscio, Informatics Corporation;
- John F. Gibbons II, Private Consultant;
- Eric B. Oswald, Private Consultant;
- Darrell D. Porter, Science Applications International Corporation; and
- Glen L. Sjoblom, Private Consultant.

Florie A. Caporuscio has a Ph.D. in Geology and more than 10 years of applied pertinent experience, including having served as the Acting Section Chief, WIPP Technical Review, at EPA Headquarters' Office of Radiation and Indoor Air and as a Staff Geologist at EPA Region II. In addition to Dr. Caporuscio's highly relevant regulatory expertise, his pertinent technical qualifications include extensive expertise in site characterization, geochemistry, radionuclide transport in geological media, and related conceptual models.

John F. Gibbons II has a Ph.D. in Geomechanics and more than 20 years of relevant experience, including having served as the Technical Director of Applied Research Associates for site characterization technology research and development activities augmented by involvement in numerous site characterizations. Dr. Gibbons' site characterization and technology research and development (R&D) experience is particularly pertinent for peer reviews involving geology, tectonics, hydrology, and related conceptual models.

Eric B. Oswald has a Ph.D. in Hydrology and Water Resources Administration and more than 25 years of applied pertinent technical and regulatory experience. Dr. Oswald's technical qualifications include extensive surface and groundwater flow system analyses and control, contaminant transport, and related conceptual models.

Darrell D. Porter has a Ph.D. in Mineral Engineering and more than 34 years of experience in earth sciences programs with emphasis on rock mechanics. Dr. Porter's pertinent technical qualifications include extensive involvement in site characterization, regulatory compliance, QA, and technical review activities in support of deep geologic repository development.

Glen L. Sjoblom has a M.Sc. in Chemical Engineering and more than 26 years of experience in environmental radiation protection, including having served as the Director of Radiation Programs at the EPA during the development and promulgation of 40 CFR Part 191. Mr. Sjoblom's extensive environmental radiation protection experience also includes serving as Special Assistant to the Director of the Office of Inspection and Enforcement and Deputy Director of the Division of Industrial and Regulatory Medical Nuclear Safety at the NRC. Mr. Sjoblom's pertinent technical qualifications include chemistry, waste characterization, deterministic and stochastic risk and safety analysis, and environmental protection activities in support of deep geologic repository development.

Charles R. Wilson has a Ph.D. in Civil Engineering–Groundwater and more than 26 years of relevant experience in earth sciences programs. Dr. Wilson's pertinent technical qualifications include lead roles in the geology, hydrology, geochemistry, and geotechnical engineering disciplines on teams involved in site characterization, model development, and modeling of landfills; water resources; groundwater flow systems; contaminant and radionuclide transport; and nuclear waste repositories in the United States and abroad.

Additional details regarding the technical qualifications and independence of the panel members are provided in Appendix A of the July 1996 peer review report (see CCA Appendix PEER). Each panel member's background was carefully reviewed to ensure his strong qualifications, verify his independence from other WIPP work, and confirm the absence of conflicts of interest.

The initial peer review, described in detail in the CCA and summarized in this chapter, was conducted from April through August 1996. After orientation and training, the panel was provided draft conceptual model descriptions and other relevant information and was briefed by WIPP project staff. Panel members also had access to the Sandia National Laboratories (SNL) Nuclear Waste Management Program Library and to reports of prior peer reviews.

The objective of the review was to determine the adequacy and reasonableness of 24 conceptual models representing features, events, and processes (FEPs) involved in assessing the long-term performance of WIPP. As stated in the CMPR report:

> A conceptual model is a statement of how important features, events, and processes) such as fluid flow, chemical processes, or intrusion scenarios are to be represented in performance assessment. To be used in performance assessment, the conceptual model must be successfully translated into analytical statements and mathematical analogs. The Panel reviewed in detail the twenty four conceptual models against criteria of the EPA....The Panel also made an assessment of the information used and whether the conceptual model is adequate for implementation in an overall performance assessment model.

Per the criteria of 40 CFR Part 194, the peer review was conducted in a manner compatible with the provisions of NUREG-1297. The 8 adequacy criteria from NUREG-1297 were used as a basis for review of each model (see Section 9.2.1).

The first CMPR Report was issued in July 1996 (a copy of the CMPR Report is provided in CCA Appendix PEER). The panel initially concluded that 13 of the models were adequate for implementation and that the remaining 11 models were not adequate for use in PA. The DOE provided additional information in response to the panel's concerns, and the panel subsequently determined that the responses for 6 of those 11 models reasonably addressed their concerns. In addition, the panel concluded that some of the responses (multiple concerns were identified for some models) relating to three additional models also reasonably addressed its concerns. Finally, the panel concluded that responses regarding three models did not reasonably address its concerns; however, one of these models was determined to have no consequence to PA. The DOE's justification for using these unresolved models is discussed in Section 9.3.1.2 of the CCA and is briefly described in the same section of this chapter.

The 24 models reviewed by the panel are listed in Table 9-1. Also provided are the panel's conclusions about the adequacy of the models and whether the panel believed that the DOE's responses reasonably addressed its concerns about those models it determined to be inadequate.

Table 9-1. Adequacy of WIPP Conceptual Models

Model	Report Findings	DOE Response Reasonable?
Disposal System Geometry	Adequate	Not Applicable
Culebra Hydrogeology	Not Adequate [1]	Yes
Repository Fluid Flow	Not Adequate	Yes
Salado	Adequate	Not Applicable
Impure Halite	Adequate	Not Applicable
Salado Interbeds	Not Adequate	Yes
DRZ	Adequate	Not Applicable
Actinide Transport in the Salado	Adequate	Not Applicable
Units Above the Salado	Not Adequate [1]	No[1]
Transport of Dissolved Actinides in the Culebra	Adequate	Not Applicable
Transport of Colloidal Actinides in the Culebra	Not Adequate	No
Exploration Boreholes	Not Adequate	Partially[2]
Cuttings and Cavings	Adequate	Not Applicable
Spallings	Not Adequate	Yes
Direct Brine Release (DBR)	Not Adequate	No
Castile and Brine Reservoir	Not Adequate	Partially[3]
Multiple Intrusions	Adequate	Not Applicable
Climate Change	Adequate	Not Applicable
Creep Closure	Adequate	Not Applicable
Shafts and Shaft Seals	Adequate	Not Applicable
Gas Generation	Not Adequate	Yes
Chemical Conditions	Not Adequate	Partially[4]
Dissolved Actinide Source Term	Adequate	Not Applicable
Colloidal Actinide Source Term	Adequate	Not Applicable

[1] Although the model was found to be inadequate, it was determined to have no consequence to PA.
[2] The panel concluded that responses to three of their four concerns were reasonable.
[3] The panel concluded that responses to two of their three concerns were reasonable.
[4] The panel concluded that responses to two of their three concerns were reasonable.

Section 9.3.1.1 provides a brief description of the panel's discussion on the models it deemed adequate. Section 9.3.1.2 of the CCA provided a description of the panel's discussion on the models deemed inadequate; the DOE's responses to the panel's concerns; the panel's comments on those responses; and the DOE's technical position on those concerns wherein the panel concluded that the responses did not reasonably address its concerns. Section 9.3.1.2 of this chapter summarizes that discussion.

The same panel continued additional reviews after the submission of CCA, with supplementary reports published in December 1996, January 1997, and April 1997. These supplementary peer reviews are described in Section 9.3.1.3.

9.3.1.1 Adequate Models

The following excerpts are from the CMPR Report. They address those 13 models the panel determined to be adequate.

9.3.1.1.1 Disposal System Geometry

> The conceptual model for the disposal system geometry provides a suitable framework for modeling the important processes and their interactions in the disposal system. . .The concept that the spatial effects of processes and interactions can be represented in two dimensions is defensible. The simplification in the system representation and computational method to simulate the two dimensions are defensible and adequate for implementation. The basic grid framework for representing the material properties of the disposal system, adjacent DRZ [disturbed rock zone], geologic formations, and intrusion scenarios is adequate and the proposed use of a finite difference method to connect the nodes and generate flow fields is also defensible and adequate for implementation.

9.3.1.1.2 Salado

> Given that the conceptual model predicts that there will be enough brine to corrode the waste and that other assumptions appear conservative, making other impacts unlikely, the model is adequate for its intended use. . .The conclusions appear to be valid. Estimates of inflow volumes from the mechanisms proposed in the model appear to be reasonable. . .The model is adequate for implementation.

9.3.1.1.3 Impure Halite

> Although differences in the behavior of pure and impure halite, variable degrees of impurity, and complexities of stratigraphic distribution of zones of impurity exist, the modeling of all halite rocks in the Salado as impure halite is an acceptable model simplification. . .The model appears to be adequate for the same reasons that the overall Salado model is adequate. Brine inflow sufficient to corrode the waste and to drive biogenic degradation is assumed. For error to be significant, brine inflow would have to be very large, which is unlikely. . .The conclusions drawn on the basis of the impure halite model are valid for PA purposes.

9.3.1.1.4 Disturbed Rock Zone

> All observed considerations of analysis, study, and proposed engineered applications regarding the DRZ and its impacts on effective shaft sealing appear to be valid. The understandings developed of DRZ phenomena and data reveal it is critical to engineering waste containment overall because of its potential for negative impact on shaft seals permeability and integrity and fluid flow in the rooms and their seals. It appears that all considerations of this impact and the conclusions discussed here are sound and

valid. . .The panel concludes that the present DRZ model is adequate to be implemented in performance calculations.

9.3.1.1.5 Actinide Transport in the Salado

It seems DOE has provided a very rational way to "lump" all the various solubilities of dissolved actinides and to describe how the four main types of colloids will be "lumped" for transport. Both of these source terms have complex properties that could have been negated by the "lumping" factor. . .These two philosophies of solubility "lumping" have been clearly explained for dissolved and colloidal actinide transport. . .by the principal investigator and by this means the implementation was determined to be adequate. . .this model is wholly adequate and reasonable for implementation.

9.3.1.1.6 Transport of Dissolved Actinides in the Culebra

It is concluded that a dual porosity model is adequate for dissolved actinide transport analyses if ranges of model parameters are chosen properly in light of uncertainties. . .The conclusion that the actinide transport in the Culebra can be adequately modeled in a dual porosity model, with advective transport in the main flow porosity, diffusion into and physical and chemical retardation in the rock matrix porosity, is valid. . .The conceptual model appears compatible with other models it intersects with directly.

9.3.1.1.7 Cuttings/Cavings

This model is fundamentally appropriate. It is based on straightforward analysis, concepts, and technology that is well developed and believed to be adequate for depicting that part of the consequences of a waste room penetration by a borehole drill that is covered by this model....The CUTTINGS_S model contains well thought out and evaluated mathematics based on researched and established fluid flow technology and science. . .This model is sufficiently developed and uncomplicated that no serious concerns were found. It appears to be capable of accurately representing the waste that might be removed during a drilling intrusion and is fully adequate for implementation in support of the WIPP performance assessment.

9.3.1.1.8 Multiple Intrusions

The conceptual model for multiple intrusions is fundamentally sound and appropriately conservative, given the simplifications that are required to model a complex set of conditions in an efficient manner. . .The application of the conceptual model to the numerical model is adequate, again given the simplifications that are required to model a complex set of conditions in an efficient manner. . .The Multiple Intrusion conceptual model is adequate for implementation in performance assessment.

9.3.1.1.9 Climate Change

The climate change conceptual model represents a reasonable and defensible range of potential future climate extremes for incorporation into the performance assessment. The conceptual model includes a range of conditions, bounded by reasonably foreseeable future climates and their effects that are adequate to represent impacts to groundwater flows in the Culebra Dolomite Member of the Rustler Formation. In addition to providing adequate representation of conditions for implementation, the background research and analysis supporting the formulation of the conceptual model for climate change provides adequate information for satisfying EPA guidance.

9.3.1.1.10 Creep Closure

The adequacy of the Creep Closure conceptual model is demonstrated by its predictiveness of room closure in existing WIPP excavations. The uncertainties inherent in the model must be assessed through the sensitivity of the porosity surface calculation. The model appears to be adequately predictive. . .The porosity surface calculation appears to address the complex issues of timing among processes and provides a means of choosing representative parameters for individual process with respect to uncertainty about process results and timing during dynamic process evolution.

9.3.1.1.11 Shaft and Shaft Seals

Comments concerning two issues from the preceding section are also applicable to the model's adequacy for implementation: 1) further analysis of the salt compaction data base, firmed up with additional data, is important to support parameter permeability values, and 2) an analysis has not been found to assure the shaft monolith does not create a shear zone at the shaft perimeter interface. Aside from these, the foregoing discussions outline an insightful piece of scientific and engineering work. The shafts and seals program is well thought through and the areas of perceived concern have been addressed to various degrees of detail, each believed sufficiently adequate to support qualifying this model as adequate to proceed in supporting performance assessment.

9.3.1.1.12 Dissolved Actinide Source Term

The true unknowns are to be found in the assumptions that the chemistry rapidly approaches equilibrium and that the waste has uniform characteristics and inventory. These fundamental assumptions are a basis of the conceptual model and are most probably adequate and reasonable. . .This model has turned out to be a very strong representation of how actinides would dissolve in the two major brines (Salado and Castile) of the repository and is adequate to support performance assessment.

9.3.1.1.13 Colloidal Actinide Source Term

Since this model is inexorably linked to the solubility concentrations of the dissolved actinide source term, one may conclude that this model is valid contingent on the validity of the other model (which was determined to be valid, with minor caveats)... The Colloidal Actinide Source Term model is a reasonable, if somewhat overly conservative representation of how actinides would sorb onto colloids in the two major brines (Salado and Castile) available for the repository. This conceptual model is adequate to support performance assessment.

9.3.1.2 Inadequate Models

As indicated above, the CMPR panel initially determined that 11 of the models they reviewed were inadequate. The CMPR panel concerns, the DOE's interpretation of the panel's concerns (Statement of Issue), the DOE response to the panel's concerns (Response to Issue), and the panel's reaction to the interpretation and responses (Peer Reviewer Consideration of Response) are provided in CCA Section 9.3.1.2. In those instances in which the panel determined the response did not reasonably address its concerns, the DOE developed additional information regarding its position (DOE Technical Position versus Panel Issue). These are also provided in CCA Section 9.3.1.2. For pre-CCA peer reviews, the issues raised by the panel and the panel's responses after considering the DOE responses are mentioned in this chapter, but the detailed exchanges between the DOE and the panel are not repeated.

9.3.1.2.1 Peer Review Panel Concerns – Culebra Hydrogeology

> No conceptual model which explains the variability of hydrologic properties and processes in the Culebra at a scale which is useful in correlating those properties in the numerical hydrologic flow model was developed.
>
> An extensive hydrologic testing database and an apparently adequate numerical flow model were developed as a substitute for performance assessment purposes.
>
> Although the Culebra conceptual model was found to be inadequate to support numerical modeling, this inadequacy was inconsequential for performance assessment because an extensive hydrologic database was developed and serves as an adequate substitute to support numerical modeling.

After consideration of the DOE response, the panel concluded that the DOE understood the issues and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.2 Peer Review Panel Concerns – Repository Fluid Flow; First Concern

> The conceptual model and its two-dimensional (2D) numerical implementation may unrealistically restrict brine movement within the repository to the anhydrite interbeds because of the shallow depths of the borehole and shaft model cells. These restrictions could result in underestimating brine migration in the interbeds toward the accessible environment.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and the response reasonably addressed the panel's concern. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.3 Peer Review Panel Concern – Repository Fluid Flow; Second Concern

> The conceptual model and its two-dimensional numerical implementation do not include the presence of the unplugged ERDA-9 borehole within the walls of the operations area. This borehole could provide a pathway for gas and possibly brine to the ground surface,

> and no description of the plugging plan for this hole was seen in the documentation provided by the Panel.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.4 Peer Review Panel Concern – Repository Fluid Flow; Third Concern

> The sensitivity of model results to the selection of constant permeability values for the waste, panel seals, and repository DRZ has not been evaluated for the current PA. Early time permeabilities may be significantly greater than the model parameter for each of these media, and could lead to underestimation of radionuclide releases.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.5 Peer Review Panel Concern – Repository Fluid Flow; Fourth Concern

> The long-term performance of the panel closure seals has not been subjected to a detailed engineering evaluation of the type performed for the shaft seal. The role of the panel seals in restricting brine flow among the waste panels and into other parts of the repository is an important element of the conceptual model and its implementation in PA.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.6 Peer Review Panel Concern – Salado Interbeds

> The conceptual model does not consider how the physical properties of the bounding clay seams affect model fracture propagation and permeability. Ignoring the characteristics of the clay seams may significantly overestimate the threshold pressure at which repository gases may be released.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.7 Peer Review Panel Concern – Units Above the Salado

> The conceptual models and the testing database are inadequate to exclude the Dewey Lake Redbeds and the Magenta Dolomites as potential transport pathways for radionuclides in the event of an intrusion.

After consideration of the DOE response, the panel concluded that the DOE understood the issues; however, the panel concluded that the response did not reasonably address its concerns. The panel noted, however, that the inadequacy of the model is of no consequence to the PA. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.8 Peer Review Panel Concerns – Transport of Colloidal Actinides in the Culebra; First Concern

> The conceptual model does not adequately support the assumption that dissolved actinides will not interact with Culebra colloids. Ignoring this phenomenon could overestimate the travel time calculated for radionuclides to reach the accessible environment.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address its concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.9 Peer Review Panel Concern – Transport of Colloidal Actinides in the Culebra; Second Concern

> The experimental K_ds determined for this model are not fully defensible. Such values may overestimate the retardation of actinides in the Culebra.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address their concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.10 Peer Review Panel Concerns – Transport of Colloidal Actinides in the Culebra; Third Concern

> Recent experimental work to support assumptions and data for this model has not yet been published and were not available for panel review.

After consideration of the DOE response, the panel concluded that insofar as this issue was not based on a technical issue, the panel was not requested to review the response.

9.3.1.2.11 Peer Review Panel Concerns – Exploration Boreholes; First Concern

> The potential for releases or changes in repository conditions from borehole penetrations in the operations and experimental areas of the repository does not appear to have been evaluated. Radionuclides that may have migrated into those areas through the panel closures by diffusion or other transport mechanisms could be released to the ground surface, and gas pressures could be relieved by such boreholes. Also, brine could migrate into those areas from a borehole and then into the waste panels.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.12 Peer Review Panel Concerns – Exploration Boreholes; Second Concern

> The assumption that shorter (40 m) (131.2 ft) borehole plugs beneath the repository horizon will not significantly degrade during the 10,000-year regulatory time frame has not been adequately supported. For the two- and three-plug configurations, degradation of these plugs could result in creation of a low permeability pathway for fluid migration between the Bell Canyon and the repository. For the three-plug configuration, degradation could result in increased fluid migration from a Castile brine reservoir to the repository.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.13 Peer Review Panel Concern – Exploration Boreholes; Third Concern

> The possibility that an effect on the repository could result from Castile brine encountered in an E1 borehole that is assigned a three-plug configuration does not appear to have been considered in the conceptual model. Castile brine could enter the repository during drilling before the borehole is cased and result in increased rates of corrosion, waste degradation, and gas production

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address its concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.14 Peer Review Panel Concerns – Exploration Boreholes; Fourth Concern

> The sensitivity of the performance assessment to the simplified approach taken to determine reference conditions for BRAGFLO output does not appear to have been evaluated for the current model configuration. If reference conditions are not provided at sufficiently frequent time intervals, the modeling results may be erroneous.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.15 Peer Review Panel Concerns – Spallings; First Concern

> The conceptual model for channel flow of gases toward an exploratory borehole appears to be valid but has not been adequately evaluated. Spallings is a potentially important mechanism for direct waste release to the ground surface.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.16 Peer Review Panel Concern – Spallings; Second Concern

> The conceptual model for waste erosion by flowing gases has not been adequately defined. The model describing the source(s) of waste erosion resistance and the parameter(s) characterizing that resistance have not been adequately evaluated. Errors in this conceptual model could lead to over estimating or under estimating the volume of waste released in the spallings process.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.17 Peer Review Panel Concern – Spallings; Third Concern

> The waste has not been adequately characterized and the understanding of its physical properties in its decayed state has not been adequately developed to support the Spallings model. An adequate understanding of waste erosion processes requires an adequate understanding of the properties of the waste.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.18 Peer Panel Concern – Direct Brine Release; First Concern

> The basis for the assumption that radionuclides do not accompany the direct discharge of Castile brine has not been adequately supported. This assumption could lead to underestimating radionuclide releases.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel determined that the response did not reasonably address their concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.19 Review Panel Concern – Direct Brine Release; Second Concern

> Radionuclide transport through entrainment of brine and waste solids in rapid, two-phase liquid/gas releases during inadvertent borehole intrusions does not appear to have been evaluated. This transport mechanism may be an important component of the conceptual model.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address their concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue." The CMPR panel further addressed several issues related to the spallings conceptual model in 1996-97 after submission of the CCA. In addition, a new peer review panel addressed the spallings issues in 2003. Results of these additional peer reviews are discussed in Section 9.3.1.3 and the reports are included in Appendix PEER-2004.

9.3.1.2.20 Peer Review Panel Concern – Direct Brine Release; Third Concern

> Releases resulting from flow into an exploration borehole intersecting a disturbed rock zone in the wall of a waste panel do not appear to have been evaluated. Large, open fractures in the walls could significantly increase the local halite permeability, allowing gas and brine to migrate through the borehole to the ground surface.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address their concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.21 Peer Review Panel Concerns – Castile Formation Brine Reservoirs; First and Second Concerns

> The basis for excluding larger, potentially depressurized brine reservoirs from performance assessment has not been adequately supported. Larger reservoirs may have greater brine flow volumes and may result in greater radionuclide releases.

> The basis for the concept of reservoir depletion through previous borehole penetrations has not been adequately supported. Non-depleted reservoirs may have greater brine flow volumes and may result in greater radionuclide releases.

After consideration of the DOE response, the panel concluded that the DOE understood the issues and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.22 Peer Review Panel Concern – Castile Formation Brine Reservoirs; Third Concern

> The expected probability of encountering pressurized brine beneath the waste panels has not been adequately supported, nor has the basis for apparently ignoring the quantitative value of site-specific geophysical data been presented. Unrealistically low probabilities of encountering brine may result in underestimating radionuclide releases.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address its concern. See CCA Section 9.3.1.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.1.2.23 Peer Review Panel Concern – Gas Generation; First Concern

> The conceptual model does not consider aluminum in the waste, steel in the rock bolts and netting, radiolysis of water by undissolved alpha emitters, and radiolysis of plastics and cellulosics as sources of additional hydrogen (H), oxygen (O_2), and other gases. Ignoring gases generated by these effects could result in underestimating the gas pressure in the repository.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.24 Peer Review Panel Concern – Gas Generation; Second Concern

> An adequate basis has not been presented for the assumption of complete and rapid carbon dioxide removal by magnesium oxide (MgO) in the waste panels. The chemical conditions in the repository would significantly change if the MgO did not function as planned, and could result in higher radionuclide releases than the model would estimate.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and the response reasonably addressed this gas generation concern. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.25 Peer Review Panel Concern – Gas Generation; Third Concern

> An adequate basis has not been presented for ignoring the effects of heat generation from corrosion and microbial actions. Higher ambient repository temperatures could increase the rates of chemical reactions, fluid flow, and halite creep.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.26 Peer Review Panel Concern – Chemical Conditions; First Concern

> The combined temperature increase (due to radioactive decay and exothermic reactions) and its effect on repository conditions has not been adequately addressed. Significantly higher repository temperatures could accelerate chemical reactions, fluid flow, and halite creep rates.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.1.2 for details of the DOE response.

9.3.1.2.27 Peer Review Panel Concerns – Chemical Conditions; Second and Third Concerns

> Phase equilibria have not been critically assessed within the chemical parameters of the conceptual model. A major element stable phase that was overlooked could significantly alter the chemical conditions of the repository and vary the actinide source terms.

> The MgO backfill has not been demonstrated to be able to react completely with carbon dioxide (CO_2) generated by microbial action. If the MgO backfill did not react as planned, the pH buffering capability of the repository would be significantly compromised, and could result in underestimating the actinide source terms.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel determined that the DOE response did not reasonably address their phase-equilibria concern. The panel did conclude that the response reasonably addressed their concern regarding the MgO backfill/CO_2 concern. See CCA Section 9.3.1.2 for details of the DOE response, including "DOE Technical Position versus Panel Issues."

9.3.1.3 Post-CCA Conceptual Models Peer Review

The CMPR panel (CMPRP) started its work in April 1996 and submitted its first report in July 1996. The July 1996 report is discussed in Sections 9.3.1.1 and 9.3.1.2, and was included in CCA Appendix PEER. DOE retained this panel after submitting the CCA to continue addressing the issues that were not completely resolved, although acceptable from a PA point of view. The panel issued three supplementary reports between December 1996 and April 1997. The results of these additional reviews are described in Sections 9.3.1.3.1 through 9.3.1.3.3, below, and the three supplementary reports are included in Appendix PEER-2004.

Two additional conceptual models peer reviews on Salado flow and spallings were conducted in 2003. These are described in Sections 9.3.1.3.4 and 9.3.1.3.5 below, and the two reports are included in Appendix PEER-2004.

9.3.1.3.1 Conceptual Models Supplementary Peer Review – October to December 1996

In its July 1996 report (see Section 9.3.1.2), the CMPRP concluded that of the 24 conceptual models, 13 were adequate for implementation and 11 were not, based on the panel review of the available information and the stated EPA criteria. The DOE reconvened the panel in October 1996 to review changes to the conceptual models, the DOE responses to the findings in the July 1996 panel report, and information available in the CCA (DOE 1996a). In December 1996, the panel issued a report (Docket II-G-12) supplementing the July 1996 report that assessed the changes to the models and DOE responses. For the December 1996 supplementary report, the panel evaluated DOE responses to the panel's findings in the July 1996 report, additional information available since the earlier report, changes that were made to 11 of the models, and the results obtained from implementing the models in PA. Based on this evaluation, the panel's concerns were resolved for all but two of the 11 models previously identified as inadequate. In addition, the new information obtained during this supplemental evaluation did not change the panel's previous conclusions of the 13 models that were found to be adequate.

The two models that remained inadequate in the panel's evaluation were the Chemical Conditions and the Spallings.

For the Chemical Conditions model, the panel's concern related to the ability of the MgO backfill to perform as assumed in PA. The panel stated:

> The ability of the MgO backfill to react completely and rapidly with CO_2 to buffer the chemical system and limit actinide solubilities has not been adequately substantiated by experimental physical results that correctly simulate conditions in the repository. Although the pH buffering assumptions are of considerable importance to many other conceptual models, the conclusion that the MgO will in fact perform as assumed has not been adequately supported.

A full discussion of the panel's position on the Spallings model is contained in Section 3.14 of the panel's report (See Appendix PEER-2004, Section PEER-2004-1.1.3). In summary, the panel stated in Section 5.0 of its report:

> An adequate basis for the parameters used in the mathematical expression of the model has not been developed. In particular, ignoring capillary forces and correlating tensile strength with surface erosion have not been adequately supported by either first principles or experiment.
>
> The principal assumptions upon which the mathematical model is based appear to be incomplete. Waste removal by entrainment in gas flow is expected to occur in a highly dynamic sequence principally involving a spalling process driven by gas flow out of the porous waste normal to the eroded surface. Subsequent erosion by gas flow parallel to the eroded surface in pathways that are not expected to be the primary effect controlling the volume of spall, particularly in early times. In addition, the DOE has not adequately shown that the steady-state assumptions of the model conservatively approximate releases associated with the dynamic process of spall, and the possibility of transonic velocities has apparently not been considered.
>
> The experiments conducted in support of this model appear to have been designed to reproduce the assumptions upon which the model is based, rather than to simulate the dynamic repository system. Although the experiments may support adoption of specific model parameters, they do not demonstrate that the model adequately represents future states of the repository.

9.3.1.3.2 Conceptual Models Second Supplementary Peer Review – January 1997

DOE reconvened the Conceptual Models panel in January 1997 to review additional information developed in response to the remaining issues of the two models, Spallings and Chemical Conditions, found inadequate in December 1996. The panel issued a second supplementary report in January 1997 to supplement the panel's July 1996 and December 1996 reports. In summary, the panel concluded that the Spallings model and the Chemical Conditions model remained inadequate to represent the future states of the repository. An account of the DOE's new presentations to the panel and the panel's responses are given below.

9.3.1.3.2.1 *The Spallings Model in the Conceptual Model Second Supplementary Peer Review*

The DOE responded to the panel's continued concerns through the SNL Spallings Release Position Paper (Hansen et al. 1997a), oral presentations, subsequent discussions, and presentations of additional information. The position paper and initial oral presentations addressed the panel's concerns by grouping them into categories of waste characterization, analog comparisons, and conceptual model issues.

The waste characterization information discussed the physical condition of the waste capable of release by a spallings process, the waste strength, and the expected significance of these results relative to spallings releases. Key points made were that any waste capable of spallings release would be at least partially degraded and have some moisture content, because without the presence of brine, the elevated gas pressure that drives the spallings process could not exist. The model assumption that the degraded waste would have the average characteristics of fine sand were considered by DOE to be highly conservative, because not all of the waste would have degraded to that end state during the 10,000-year regulatory period. The 1 psi (6,895 pascals) cementation strength assumed in the model was also considered conservative, and experimental results were presented showing that dried samples of sand saturated with WIPP brine had indirectly determined tensile strengths that averaged 49 psi. Higher average tensile strengths ranging up to 114 psi were found when NaCl and MgO were added to the brine. The DOE concluded that waste strength dominates spallings releases, the assumed waste strength of 1 psi

(6,895 pascals) was conservatively low, and degraded waste will be heterogeneous and cemented, significantly impeding erosion.

Analog comparisons were presented for spallings-type releases induced by pressure surging to stimulate methane (CH_4) production from coal beds, industrial techniques to remove cuttings by air injection during borehole drilling, the downhole pressure gradient requirements for removal of hydrofracture proppants, wellbore stability and sand production as a function of fluid velocities, and the limitations of the borehole as a transport pathway.

A DOE team made preliminary scoping calculations using an elastic, Mohr-Coulomb model of waste that would be released by tensile failure using the pressure-transient data described above and ranges of values for the key waste strength properties. Several cases were run in which assumed waste compressive strength and internal friction were varied. The details of these analyses are presented in Hansen et al. (1997b). The results indicated that the volume released from a 1-m (3.28-ft) thick waste horizon (representing the fully compacted state of the waste) ranged from 0.37 to 0.59 m^3 (13.06 to 20.8 ft^3), and approached approximately 0.6 m^3 (21.1 ft^3) as the waste tensile strength approached zero.

In response to the DOE's presentations, the panel stated that the additional analog, waste strength, model descriptions, and calculational information provided were either not adequately correlated with WIPP repository conditions or not sufficiently complete or supported to determine that either the spallings model or the results obtained from that model were conservative. Details of the panel's response can be found in Appendix PEER-2004, Section PEER-2004-1.1.4.

9.3.1.3.2.2 *Chemical Conditions Model in the Conceptual Model Second Supplementary Peer Review*

The DOE summarized a calculation of complementary cumulative distribution functions (CCDFs) intended to show the importance of MgO on repository system performance. The CCDFs without MgO present showed increased releases compared to those with MgO present. Releases with MgO present predominantly result from cuttings/cavings and spallings, but without MgO present, the contribution from direct brine release (DBR) significantly increases. DOE emphasized that the mean CCDF without MgO present still remained lower than the EPA limit. DOE also provided additional results of experiments with MgO from the ongoing test program.

The panel examined the various assumptions and parameters used to compute the CCDFs without MgO present and felt that the differences in CCDFs with and without MgO represented the degree of the chemical getter's importance to repository performance. The panel stated its belief that adding the MgO would positively benefit and not detract from the repository performance. However, the panel identified a few additional factors to include for such a CCDF calculation to be definitive, including the effect on corrosion rates, gas generation rates, and pressures over time. However, inasmuch as calculations without MgO showed that DBR would become an important contributor to overall releases, the Chemical Conditions model was a significant contributor to the future states of the repository. Furthermore, according to the panel, the additional results from the ongoing test program, while interesting, were not sufficient to resolve the panel's concerns about MgO effectiveness.

The results presented to the panel concerned the effect of CO_2 diffusion into the MgO pellets. Test runs of four days following dye infusion indicated that in 24 hours, the dye would travel through the reaction rims to the center of the pellet. However, the panel stated that the test runs were short, the reaction rims were thin and may not have been fully formed, and there were no transient information or bounding calculations to support a conclusion regarding the role of the reaction rims in impeding CO_2 diffusion. According to the panel, information was not available on the diffusion rate of CO_2 into the MgO pellets, especially as a function of reaction rim thickening. The panel believed that the aforementioned test program had not sufficiently progressed to provide a definitive verification that the MgO would perform as planned under repository conditions. Therefore, the panel concluded that the Chemical Conditions model was not sufficiently developed to adequately support PA. For the DOE response to this conclusion from the panel and the panel's final conclusion, see Section 9.3.1.3.3.1.

9.3.1.3.3 Conceptual Model Third Supplementary Peer Review – April 1997

In its January 1997 second supplementary report, the panel continued to find two of the models inadequate to represent the future states of the repository. For the two models found inadequate, Spallings and Chemical Conditions, the panel identified the remaining issues. In the third supplementary report (Docket II-G-22), the panel considered the DOE's April 1997 responses to these remaining issues. The DOE's responses as well as the panel's evaluation of these responses, are presented in Section 3 of the third supplementary report (see Appendix PEER-2004, Section PEER-2004-1.1.5).

For the Spallings model, the panel concluded that the predicted volumes of spalled materials presented in the WIPP CCA are reasonable based on additional consideration of processes that could lead to spalled releases. The panel also concluded that the MgO backfill component of the Chemical Conditions model will function as assumed in the CCA and that this model adequately represents the future states of the repository. Details of the DOE submission to the panel in April 1997 (in response to the panel's findings in the first and second supplementary reports) are provided in the panel's third supplementary report (Appendix PEER-2004, Section PEER-2004-1.1.5) and are summarized below.

9.3.1.3.3.1 *The Spallings Model in the Conceptual Model Third Supplementary Peer Review*

In response to the panel's finding that the existing model used to estimate spalling inadequately represented critical components of the spalling process, DOE initiated a new, mechanistically based computational approach. This approach was composed of three new computational methods to develop additional information on the spalling process. These are called the cavity growth, the quasi-static, and the numerical computation methods. This approach represented the first time that borehole hydrodynamics and cavity growth were linked. The cavity growth method was presented as the primary method for estimating spall volumes. The method simulated the entire response period of the system to an intrusion event, not just the end point. Assuming initial gas pressures and waste strength, the method accounted for the progressive mechanical response of the waste to a transient solution of gas flow in the waste and included the hydrodynamics of mud and waste ejection through the borehole. The cavity growth method predicted small spalling volumes for assumed initial gas pressures below lithostatic (14.8 MPa) (2147 psi) and a maximum spalling volume of 0.25 m^3 (8.8 ft^3).

The quasi-static method also estimated spall volumes using the same mechanisms and approach as the cavity growth method, but not in a fully coupled manner. This method predicted pore pressure gradients from a consideration of borehole and porous media flow, and used these gradients to compute stresses, failure, and spall volumes. The method was applied to estimate gas volumes, gas pressure distributions, and flow rates for comparison to those predicted by the cavity growth. Graphic comparisons of gas flows and pressures predicted by the cavity growth and quasi-static methods illustrated close agreement.

The numerical method was presented as a tool for evaluating complexities not clearly represented by the other methods. The numerical method couples fluid pressure to the stress response in the waste following a drilling intrusion. Numerical calculations implemented through various computer codes were used to investigate solids mass transport, sensitivity of waste panel geometry, and effects of waste heterogeneity, in addition to predictions of gas pressures and flow rates. Numerical calculations were applied to predict gas pressures and flow rates for comparison to semi-analytic results. The numerical calculations consistently predicted lower pressure gradients and gas flow rates than the other methods. The gradients and rates predicted by the numerical method were significantly lower than those of the other methods at early time steps. Investigations of layered and random configurations of heterogeneous waste using numerical calculations resulted in reduced key parameters that determine spalling volume. Solids mass transport was investigated and determined to be limited prior to mud ejection. Tensile strength was determined to govern the system response, thereby minimizing the overall effects of waste panel geometry and flow properties.

In response to the panel's concern about the properties of the waste that would influence the spalling process, the DOE developed analogs for waste based on ranges of waste contents, corrosion, and biodegradation that could be present following extended exposure to WIPP conditions. The surrogate samples contained varying amounts of corroded and uncorroded iron metal, including addition of goethite, crushed glass and soil, salt and concrete, and MgO, in some cases. Physically degraded paper, plastic, and peat were added to represent chemically degraded organics in the waste. These surrogate waste materials were mixed with brine and consolidated to either 5 or 15 MPa (725 to 2176 psi) to simulate repository conditions. Some of the samples were subsequently dried. Standard testing procedures were used, including Brazilian and hollow cylinder tensile tests, unconfined and triaxial compression tests, and permeability tests. Various parameters, including permeability, porosity, cohesion, tensile strength, compressive strength, Young's modulus, and Poisson's ratio were determined from the test results. These parameters were then used in the various analytical calculations. DOE asserted that these parameters adequately represented the degraded waste expected in WIPP.

The panel was also presented with documentation of analogs to the spalling process at WIPP, mostly rooted in petroleum production technology. The dynamic cavitation of wellbores, specifically those through coal beds, was found to have notable attributes analogous to the spalling process at WIPP. Dynamic cavitation has many similarities to the spalling process at WIPP, such as a pressure pulse phenomenon, gas-driven particulate removal, and a highly similar physical configuration. The ability to apply established computational codes and the available database of results from this analog helped to corroborate testing and/or computational results.

For the spallings model, DOE did not request the panel to reconsider its conclusion that the original model did not adequately represent the future states of the repository, and did not ask the panel to review a new model against the criteria of 40 CFR 194. The panel was instead requested to determine if the predicted volumes of spalled materials presented in the CCA were reasonable, based on additional consideration of processes that could lead to spalled releases.

In its conclusion on this issue, the panel stated:

> Upon reviewing the DOE's written materials, oral presentations, and responses to specific issues raised by the Panel, the Panel concluded that no significant issues remained regarding the reasonableness of the spallings volumes used by DOE in its CCA for the WIPP. Although the additional waste strength, analog information, and calculational results that were presented to the Panel could be further refined, the Panel determined that this information was sufficiently accurate and complete to support a conclusion that the spallings volumes used in the CCA are reasonable, and in fact appear to overestimate the actual waste volumes that would be expected to be released by the spallings process.

Detailed arguments for reaching this conclusion are provided in the panel's report (see Appendix PEER-2004, Section PEER-2004-1.1.5).

9.3.1.3.3.2 *The Chemical Conditions Model in the Conceptual Model Third Supplementary Peer Review*

The panel concluded in the second supplementary report that the ongoing test program did not sufficiently provide a definitive verification that the MgO would perform as planned under repository conditions. The panel was particularly concerned about whether the results of early tests indicated that reaction rims would inhibit the ability of the MgO to react completely and rapidly with CO_2 to buffer the chemical system and limit actinide solubility.

The DOE provided a draft report to the panel, "Chemical Conditions Model: Results of the MgO Backfill Efficacy Investigation," dated April 23, 1997, along with oral briefings on this report. This report summarized the then-available data and analyses developed from SNL Test Plan TP-97-01. DOE indicated that of the various phases formed from brine contact with MgO pellets, the initial phase, and brucite, will crystallize to nesquehonite and hydromagnesite during short to intermediate times and, over long periods, will dehydrate to magnesite. DOE stated that the brine pH and CO_2 fugacity are controlled at levels throughout the process that effectively lead to low actinide solubilities. Earlier short-term experiments at high CO_2 contact rates indicated the formation of reaction rims. The results for longer periods with high CO_2 contact rates indicated the growth of brucite films, followed by increasing density of nesquehonite needles projecting from the pellets. Shortly thereafter, hydromagnesite forms among the nesquehonite needles, as well as farther from the pellets.

DOE concluded that while there was considerable retardation of CO_2 access to the pellets, accessibility for transfer was maintained. DOE further indicated that the predominant chemical diffusing species were MgOH+ diffusing from the pellets and HCO_3 diffusing toward the pellets. This gave rise to the precipitation of hydrous magnesium carbonates outside the pellets.

DOE further indicated that, in contrast to the experiments where relatively high CO_2 fluxes occur, the brine at WIPP would become saturated with magnesium compounds before significant introduction of CO_2 species occurs. The reactions would occur at nucleation sites still farther from the pellets, further improving the contact between the reacting species and reducing the formation of reaction rims. This supported the conceptual model assumption that the CO_2 would rapidly and completely react with the MgO. The DOE also reiterated that four times the amount of MgO needed to react with the total quantity of CO_2 generated will be emplaced in the repository.

DOE reviewed the effect of MgO control of pH and CO_2 fugacity in actinide solubility, with hydromagnesite being the predominant intermediate carbonate phase. DOE concluded that most solubilities would be lower with hydromagnesite than if the transition to magnesite occurred, as assumed earlier. DOE also concluded that the results of the test program and analyses demonstrated that MgO will function in the WIPP according to the Chemical Conditions model in the CCA.

In response to the DOE's presentation described above, the panel concluded:

> Based on the information presented to the Panel in the written material and in oral discussion, the Panel concludes that the results available provide an adequate basis to determine that the MgO backfill will function according to the Chemical Conditions Conceptual Model, as used in the CCA, with respect to reaction with generated CO2 gas.

Detailed arguments for reaching this conclusion are provided in the panel's report (see Appendix PEER-2004, Section PEER-2004-1.1.5).

9.3.1.3.4 Salado Flow Conceptual Models Peer Review – March 2003

9.3.1.3.4.1 *Introduction*

Three conceptual models (viz., Disposal System Geometry, Repository Fluid Flow, and DRZ) related to the flow in the Salado used in the CCA were revised due to changes invoked by EPA or knowledge gained since the original conceptual models were developed for the CCA. The Salado Flow Conceptual Models Peer Review panel performed a peer review of the three revised conceptual models between April 2002 and March 2003 and published a report, "Salado Flow Conceptual Models Final Peer Review Report" in March 2003. This report is reproduced in Appendix PEER-2004.

This peer review was performed to fulfill the provisions of 40 CFR 194.27 that require peer reviews of all conceptual models used in any compliance application, and was conducted according to the guidance in NUREG-1297.

9.3.1.3.4.2 *Members of the Peer Review Panel*

Dr. Florie Caporuscio, Dr. John Gibbons, Dr. E. B. Oswald, and Dr. Chunhong Li performed this peer review. Their complete biography data are included in the panel's report (Appendix PEER-2004). The following is a summary of their technical qualifications and experience.

Florie A. Caporuscio has a Ph.D. in Geology and more than 10 years of applied pertinent experience, including having served as the Acting Section Chief, WIPP Technical Review, at EPA Headquarters' Office of Radiation and Indoor Air and as a Staff Geologist at EPA Region II. In addition to Dr. Caporuscio's highly relevant regulatory expertise, his pertinent technical qualifications include extensive expertise in site characterization, geochemistry, radionuclide transport in geological media, and related conceptual models.

John F. Gibbons II has a Ph.D. in Geomechanics and more than 20 years of relevant experience, including having served as the Technical Director of Applied Research Associates for site characterization technology research and development activities augmented by involvement in numerous site characterizations. Dr. Gibbons' site characterization and technology R&D experience is particularly pertinent for peer reviews involving geology, tectonics, hydrology, and related conceptual models.

Eric B. Oswald has a Ph.D. in Hydrology and Water Resources Administration and more than 25 years of applied pertinent technical and regulatory experience. Dr. Oswald's technical qualifications include extensive surface and groundwater flow system analyses and control, contaminant transport, and related conceptual models.

Chunhong Li, Ph.D., is a groundwater modeler with experience in numerical modeling for groundwater flow and transport, numerical simulations to study the influence of matrix diffusion on radionuclide transport in fractured media, and solving scaling-related problems in groundwater modeling.

9.3.1.3.4.3 *Results of the Peer Review*

The panel reviewed the three conceptual models of interest in detail, including the assumptions and scientific information used to develop the model, alternative models considered, uncertainties, adequacy, accuracy, and validity of conclusions. The panel also assessed the information used and whether the conceptual model was adequate for implementation in an overall WIPP PA. The review process and review criteria are discussed in Section 2 of the panel's report (see Appendix PEER-2004, Section PEER-2004-2.1.3).

The changed models were reviewed in the context of the WIPP PA. The review included an assessment of the reasonableness of changes in performance estimates resulting from changes in parameter ranges and in changes to, or resulting from, single values. The review evaluated changes in the conceptual structure of the models and changes in component process models and compared the performance results of the changed models with the results of the earlier models to confirm that the changes in performance estimates were reasonable in sense and magnitude. Changes in computations or in fundamental model aspects, such as gridding, were also considered. The review considered the impacts of the changed models on the other WIPP conceptual models and related issues, such as the Option D panel closures.

The panel applied the stringent assessment criteria provided in NUREG-1297, Peer Review of High-Level Nuclear Waste Repositories. The panel member qualifications, independence, and lack of organizational conflict of interest are documented in Appendices A, B, and C of the panel's report (see Appendix PEER-2004, Section PEER-2004-2.1.3).

The following is a summary of the panel's evaluation for each of the three revised conceptual models, as contained in the panel's report.

Disposal System Geometry: The changes in the Disposal System Geometry conceptual model retain the necessary features of the original conceptual model, and the grid changes appear reasonable and sound. The Disposal System Geometry conceptual model continues to be adequate. The results of a PA for the Technical Baseline Migration (TBM) illustrated that the effects of changes in the conceptual model are minimal. The Disposal System Geometry conceptual model continues to represent repository performance with no significant change from its representation in the baseline.

Repository Fluid Flow: The Repository Fluid Flow conceptual model was determined to be both reasonable and adequate for its intended purpose. The identified changes (shaft simplification, EPA mandated parameters, cellulosic molecular structure, and fluid flow paths) appear reasonable and are expected to have minimal impact. The interaction of this conceptual model with the Option D Panel closure (with revised anhydrite fracturing and "flow around" features at high pressure), and subsequent gas pressure realizations in waste panels have been illustrated by a series of TBM CCDFs that show very little resultant change. The influence of the model when coupled with the other conceptual models appears appropriate and adequate.

Disturbed Rock Zone: Four changes to the DRZ conceptual model have the potential to impact PA. These are adopting a range of limiting porosity values to replace the CCA single value for the halite and anhydrite layers in which the DRZ is developed; defining a flow path through the floor of the repository openings into Interbed #139; flow paths around the tops and bottoms of panel seals at high pressure; and an elevation change of the waste panels in the southern end of the repository. Based upon data and analyses presented by SNL, these changes appear reasonable. The change of waste panel elevation aids repository operations and is not considered a significant change. The impact of these changes on PA calculations and CCDF plots appears negligible. The impact on releases sensitive to repository pressures, saturation, and brine volume show that changes in the DRZ model do not significantly impact the predicted compliance of the repository.

9.3.1.3.5 Spallings Model Peer Review – September 2003

9.3.1.3.5.1 *Introduction*

In accordance with the requirement of 40 CFR Part 194.27, the CBFO of the DOE has conducted a peer review of the new spallings conceptual model developed for CRA-2004.

The spallings conceptual model is one of 24 conceptual models used in the WIPP PA. This conceptual model describes a potential release of degraded solid waste materials when repository gas pressure exceeds the hydrostatic pressure in the drilling fluid at the bottom of an intrusion borehole. The CMPRP found in 1997 (see Section 9.3.1.3.3.1) that the Spallings conceptual model implemented in the CCA was inadequate to describe the detailed spallings process. However, the CMPRP also concluded that "the spallings volumes used in the CCA are reasonable, and may actually overestimate the actual waste volumes that could potentially be expected to be released by the spallings process at the WIPP" (Wilson et al. 1997, Section 4). The EPA agreed with the CMPRP that the spallings conceptual model was inadequate but the results were acceptable for use in PA (EPA 1998a, Section viii; 1998b, Section 7).

After the CCA and PAVT were completed, work continued on the development of a new Spallings conceptual model that would be more technically defensible than the original model.

This independent peer review was conducted in July to October 2003 by a three-member interdisciplinary team having the requisite broad experience and expertise to address the range of issues associated with the spallings scenario and the new numerical model developed by DOE to carry out the predictive PA calculations. The peer review was conducted primarily in Albuquerque, New Mexico, at the DOE Energy Training Center (ETC). The peer review panel was given access to the conceptual model descriptions, scientific reports, briefings, and SNL staff. The panel also had access to reports of prior peer reviews and was given the full cooperation of the DOE and SNL throughout the review. Representatives of the EPA, DOE, and the New Mexico Environmental Evaluation Group (EEG) observed the SNL technical presentations and the panel's questions and deliberations.

This peer review met the regulatory requirements of 40 CFR Part 191 and the implementation of those requirements by 40 CFR Part 194. The peer review was conducted in accordance with the NRC's NUREG-1297, Peer Review of High-Level Nuclear Waste Repositories. The adequacy criteria set forth in NUREG-1297 were those used by the peer review panel for reviewing the new Spallings conceptual model. The peer review panel followed the DOE CBFO MP-10.5, Peer Review, to perform the peer review.

9.3.1.3.5.2 *Members of the Peer Review Panel*

Dr. Ching Yew, Dr. Jonathan Hanson, and Dr. Lawrence Teufel served as members of this panel and authored the panel's report. The panel members' qualifications are briefly described below. Their detailed biographies can be found in the report of the panel (Yew et al. 2003), included in Appendix PEER-2004.

Ching Yew, Ph.D., Chairman: Dr. Yew is currently a Consulting Engineer with over 40 years experience in mechanical engineering. He has a Ph.D. in Mechanical Engineering from the University of California at Berkeley. He worked for the University of Texas at Austin providing research and teaching for 32 years. He is now a Professor Emeritus in the Department of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin. Dr. Yew is a fellow of the American Society of Mechanical Engineers (ASME) and a member of the Society of Petroleum Engineers (SPE).

Jonathan Hanson, Ph.D.: Dr. Hanson has over 18 years experience as a Consulting Geophysicist. His primary focus as consultant is the development, and subsequent software implementation, of research and analysis tools used in the earth sciences, engineering, and technology. Areas within which this work has been carried out include oil field drilling dynamics and drill bit design and performance optimization, CH_4 desorption in coal, tailored pulse loading for well stimulation, Vertical Seismic Profiling (VSP) acoustic data analysis, and Coordinate Measurement Machine (CMM) analysis software for manufacturing QA.

Dr. Hanson has a Ph.D. in Geophysics from Oregon State University. He was employed by the University of California Lawrence Livermore National Laboratory from 1978 to 1985, where he worked in the Earth Sciences Division. He has published over 50 related articles and reports. He is a member of the Society of Petroleum Engineers.

Lawrence Teufel, Ph.D.: Dr. Teufel is currently a Langdon Taylor Professor in the Petroleum Engineering Department at the New Mexico Institute of Mining and Technology in Socorro, New Mexico. Dr. Teufel has over 24 years experience in petroleum and natural gas industry. He was chairman of the Petroleum Engineering Department at the New Mexico Institute of Mining and Technology Department from 1997 to 2000. He has a Ph.D. in Geology from Texas A&M University.

Dr. Teufel was employed by SNL as a member of the Technical Staff, Geomechanics Department, from 1979 to 1986, Senior Member from 1986 to 1993, and Distinguished Member from 1993 to 1999.

9.3.1.3.5.3 *The New Spallings Model*

As stated above, DOE developed and presented a new spallings model for this peer review. DR_SPALL (from Direct Release Spall) is a new numerical code written to calculate the volume of WIPP solid waste subject to material failure and transport to the surface as a result of an inadvertent drilling intrusion. The code calculates coupled repository and wellbore transient compressible fluid flow before, during, and after the drilling intrusion process. Mathematical models are included for bit penetration, multiphase (mud, salt, waste, and gas) fluid flow in the well, fluid expulsion at the surface, coupling of the well and the drilled repository, repository spalling (tensile) failure, fluidized bed transport of failed waste, and repository internal gas flow. The wellbore model is one-dimensional with linear flow, while the repository model is one-dimensional with either spherical or cylindrical flow.

Previous work (Hansen et al. 1997b) has shown that the parameter extremes most likely to be of importance to spalling releases are high repository gas pressure, low waste mechanical strength, small waste particle size (after failure), and low waste permeability. DR_SPALL was used to confirm these observations and to better establish the ranges of these parameter values that are important. Since conventional drilling practices are assumed, allowances are made for the continuous pumping of mud during drilling, the possible stoppage of the mud pump, continuous drilling after repository penetration, and the possible stoppage of drilling, based on observations made at the surface by the driller. Of course, one possibility is the continuance of pumping and drilling despite the intrusion into a high-pressure subsurface region.

DR_SPALL is based on the theory of one-dimensional, time-dependent compressible isothermal fluid flow. Somewhat different forms of that theory are used, depending on whether the flow is in the wellbore or in the repository, and whether or not the wellbore currently penetrates the repository. The wellbore and repository flows are coupled at a specified boundary by a set of conditions. Throughout the process, the drillbit can move downward as a function of time, removing salt or waste material. Flow in the well is treated as a compressible, viscous, multiphase mixture of mud, gas, salt, and possibly waste solids. Flow in the repository is treated as viscous, compressible single-phase gas flow in a porous solid. At the cavity forming the repository-wellbore boundary (following penetration), waste solids freed by drilling, tensile failure, and associated fluidization may enter the wellbore flow stream. Between the well and the repository, flow is treated according to the state of penetration.

Thus, the major elements of the new spallings model include:

- Consideration of multiphase flow processes in the intrusion borehole,
- Consideration of fluidization and transport of waste particulates from the intact waste mass to the borehole, and
- A numerical solution for the coupled mechanical/hydrological response of the waste as a porous medium.

9.3.1.3.5.4 *Criteria for the New Spallings Conceptual Model Review*

The nine criteria used by the peer review members are based on the criteria in EPA regulation 40 CFR Part 194.27, NUREG-1297, the EPA Compliance Application Guidance, and peer panel discussions.

9.3.1.3.5.4.1 Information Used to Review the Conceptual Model

This criterion is an evaluation of data and information used to review the conceptual model. It includes attributes of the disposal system learned by SNL during site characterization activities, exercising the model, and a review of the science and concepts the model is based upon. It also includes pertinent information gained during repository operation.

9.3.1.3.5.4.2 Validity of Assumptions

The validity of key assumptions in the model and its application are assessed in terms of how they might affect the validity of the conceptual model. The review addresses the comprehensive inclusion of important FEPs, and other key assumptions. Examples are the assumption of Darcy flow, use of the ideal gas law at high pressures, and the mathematical method chosen to develop the model grid.

9.3.1.3.5.4.3 Alternative Interpretations

This criterion identifies and assesses plausible alternative conceptual models considered, but not used, by DOE and the rationale for why such alternative models were not used.

9.3.1.3.5.4.4 Uncertainty of Results and Consequences if Wrong

This criterion includes an evaluation of the key uncertainties in the selected conceptual model and a discussion of the consequences if aspects of the conceptual model chosen were inappropriate or incompletely constrained for the site or subject process. This is not an exhaustive evaluation, but it does ask, "What if the model is wrong?"

9.3.1.3.5.4.5 Appropriateness and Limitations of Method and Procedures

Based primarily on the previous four criteria, this criterion assesses whether the individual conceptual model represents a reasonable approximation of the WIPP disposal system performance.

9.3.1.3.5.4.6 Adequacy of Application

This criterion assesses whether the conceptual model is adequately applied into an acceptable overall PA system. This particular assessment does not cover the relationships among conceptual models, but rather whether the significant components of the conceptual model are appropriately implemented in support of PA. For example, are the various geometrical systems and representations of the conceptual model adequately applied within the performance modeling system, or are there discontinuities between the conceptual model and its application? Also, are there alterations of important key assumptions between the conceptual model and its implementation in performance modeling?

9.3.1.3.5.4.7 Accuracy of Calculations

This criterion assesses whether the results of performance modeling using the conceptual model within the performance system are reliable and accurate to adequately simulate the physical and chemical processes represented.

9.3.1.3.5.4.8 Validity of Conclusions

This criterion judges the validity of the key conclusions based on results of the implementation of the conceptual model in the modeling framework. The key question is whether or not conclusions from model implementation appropriately relate to the expected goal of assessing the long-term performance of the WIPP disposal system. This judgment requires an evaluation of output information from the total system PA.

9.3.1.3.5.4.9 Adequacy for Implementation

This is an overall assessment of whether the conceptual model as implemented in the PA represents a reasonable approximation of the actual disposal system.

9.3.1.3.5.5 *Summary Findings of the Spallings Peer Review Panel*

This section describes the findings of the peer review panel as related to the review criteria discussed in Section 9.3.1.3.5.4. The panel reviewed the spallings conceptual model in detail, including the assumptions and scientific information used to develop the model, alternative models considered, uncertainties, adequacy, accuracy, and validity of conclusions. The panel also made an assessment of the information used and whether the conceptual model is adequate for implementation in an overall WIPP PA. The Spallings model was reviewed in the context of the overall approach to the WIPP PA. The review evaluated the structure of the conceptual model and the mathematics used to embody the model in code. The review also included an assessment of the reasonableness of outputs based on sensitivity to parameter inputs.

The panel refers to presentations by SNL. SNL developed the Spallings model and presented it to the panel on behalf of the DOE.

The complete report of the panel (Yew et al. 2003) is included in Appendix PEER-2004, Section PEER-2004-3.1.2. The following are the findings of the panel as stated in the panel's report.

9.3.1.3.5.5.1 Information Used to Review the Conceptual Model

The data and information available was sufficient to allow a thorough technical review. Necessary attributes of the disposal system are well characterized and understood. The science and concepts upon which the model is based are sound. The model has been benchmarked against other quantified experience in coal fields, and sensitivity analyses indicate the model is valid within the range of its intended use.

9.3.1.3.5.5.2 Validity of Assumptions

The validity of key assumptions in the model and its applications has been assessed in terms of how they might affect the validity of the conceptual model. The review addressed the comprehensive inclusion of important FEPs and other key assumptions. Examples are the assumption of Darcy flow, use of the ideal gas law at high pressures, and the mathematical method chosen to develop the model grid. The essential assumptions used by SNL to develop and exercise the Spallings model were found to be appropriate and valid.

Two assumptions of the model were imposed by the requirements of successful numerical implementation. These were: (1) the existence of the Drilling Damage Zone (DDZ) and (2) a characteristic averaging length required for tensile failure. The former was required for numerical stability of the code as the bit approaches and intersects the repository, and the latter is required for spalling to occur at the face of the cavity. Both of these assumptions are reasonable and have been shown, based on a limited sensitivity analysis, likely to have little effect upon model predictions. It must be emphasized, however, that the inclusion of these mechanisms was motivated primarily by numerical purposes and have not been substantiated by laboratory measurement.

9.3.1.3.5.5.3 Alternative Interpretations

During the spallings peer review, information presented and considered by the panel did not include alternatives or options for the Spallings conceptual model. The original Spallings conceptual model can be considered an alternative. In the present model development, it appears that SNL has employed the simplest and the most straightforward approach in modeling this complex and highly coupled problem. Each individual scenario is described by applying the basic physical equations. The panel concluded that this approach would provide a conservative estimation of spalling release.

9.3.1.3.5.5.4 Uncertainty of Results and Consequences if Wrong

The panel concluded that the conceptual model contains all of the necessary components to adequately represent the physics of the spalling problem. This is a highly coupled and nonlinear problem that involves a fluid-filled wellbore, pre-penetration leak-off from the repository, post-penetration depressurization of the repository, and resulting tensile failure of waste and transport of that waste to the surface.

Obviously, there will be uncertainty in the predictions. This uncertainty can be categorized as follows:

1. Uncertainty in the physical model,
2. Uncertainty associated with numerical implementation of the model, and
3. Uncertainty associated with the input parameters to the model.

The panel judged the physical model used to represent the process to be adequate. The uncertainty associated with the numerical implementation of the model falls within the category of features invoked for numerical stability or other reasons that have little justification in terms expected physical processes or actual laboratory measurement. These principally include the existence and characteristics of the DDZ and the requirement of a characteristic averaging length near the cavity wall necessary for tensile failure to occur. Probably the largest effect on prediction error will be the uncertainty associated with the input parameters to the model, most notably the waste properties.

All of these uncertainties will affect the predicted spallings volume. Some limited sensitivity analyses have been carried out at the panel's request to look at the effect of DDZ parameters and tensile stress averaging length on predicted spall volumes. These analyses suggest that, even though these parameters do affect the volumes, the effect is probably small.

The largest uncertainty will be associated with assumed material parameters of the waste that serve as input to the model. These include tensile strength, porosity, permeability, particle size, and so on. Extensive laboratory measurements of these parameters were carried out on simulated waste material under predicted in situ conditions. The uncertainty in these parameters is associated with the uncertainty in how they may be modified by degradation over time in the in situ environment. This cannot be predicted with any degree of certainty. Therefore, one must make a reasonable estimate of the possible range of these parameters and look at the variability of the model output due to this range of input.

The panel concluded that the range of waste material properties used is reasonable based on the current understanding of these parameters and how they may change in time under in situ conditions.

Based on these arguments, the panel concluded that the combined uncertainty in the model, implementation, and input will necessarily lead to some level of model prediction error. This error, however, is expected to be small and acceptable within the context of best practices.

9.3.1.3.5.5.5 Appropriateness and Limitations of Method and Procedures

Based primarily on the previous four criteria, the panel concluded that the methods and procedures used by SNL to develop and present the spallings model are acceptable and reasonably represent future repository performance.

9.3.1.3.5.5.6 Adequacy of Application

The peer review panel found the new spallings conceptual model to be adequate. The model structure is technically sound in mathematical formulation and numerical implementation. The panel also found that the model reasonably approximates the expected WIPP disposal system performance. The panel's assessment did not address the relationships among conceptual models in detail, but rather whether the significant components of the spallings conceptual model are appropriately implemented in support of PA. For example, the various geometrical systems and representations of the conceptual model appear to be adequately applied within the performance modeling system, with no significant inconsistencies in the application of the conceptual model to model the WIPP waste disposal system.

9.3.1.3.5.5.7 Accuracy of Calculations

The results yielded using the Spallings conceptual model appear reliable and reasonably accurate to adequately simulate the physical processes of the WIPP waste disposal system.

9.3.1.3.5.5.8 Validity of Conclusions

There are no specific conclusions drawn, with respect to the Spallings conceptual model, other than its ability to characterize appropriate properties, processes, and features of the repository during a potential spallings event. The panel concludes that the Spallings conceptual model reasonably represents future repository performance.

9.3.1.3.5.5.9 Adequacy for Implementation

The WIPP conceptual models, as interpreted through the various codes, are ultimately integrated at the CCDFGF where results are prepared. The integration of the conceptual models, therefore, identifies the overall WIPP PA model as a complex structure that represents 24 conceptual models through preparatory, process, flow and transport, presentation, and enabling codes.

Applying evaluation criteria to the integration of a given conceptual model, as a step in the assessment of model adequacy, results in most of the discussion focusing on the review criteria discussed in Section 9.3.1.3.5.4. For example, evaluation of information used in the integration, assumptions, uncertainties, adequacies, accuracy, and validity are all based on the conceptual model, or the implementing mathematical representation or code, being evaluated.

Because a total and complete system PA was not available for the panel to review, the overall adequacy for implementation of the spallings model integrated with the other conceptual models can only be judged at this time relative to the criteria discussed earlier in this section. Based on the review of the Spallings conceptual model, the supporting assumptions, and mathematical implementation, integration of this conceptual model with the other conceptual models is expected to be adequate.

Thus, the panel applied the stringent assessment criteria provided in NUREG-1297, Peer Review of High-Level Nuclear Waste Repositories, and concluded:

- The new Spallings conceptual model appears generally sound in its structure and reasonableness.
- The proposed implementation of the new Spallings model appears reasonable.

9.3.2 Waste Characterization Analysis Peer Review

40 CFR § 194.27(a)(2) states that a compliance application shall include documentation of peer review conducted for "waste characterization analyses as required in § 194.24(b)." 40 CFR § 194.24 (b) states:

> The Department shall submit in the compliance certification application the results of an analysis which substantiates:
>
> (1) That all waste characteristics influencing containment of waste in the disposal system have been identified and assessed for their impact on disposal system performance. The characteristics to be analyzed shall include, but shall not be limited to: solubility; formation of colloidal suspensions containing radionuclides; production of gas from the waste; shear strength; compactability; and other waste-related inputs into the computer models that are used in the performance assessment.
>
> (2) That all waste components influencing the waste characteristics identified in paragraph (b)(1) of this section have been identified and assessed for their impact on disposal system performance. The components to be analyzed shall include, but shall not be limited to: metals; cellulosics; chelating agents; water and other liquids; and activity in curies of each isotope of the radionuclides present.
>
> (3) Any decision to exclude consideration of any waste characteristic or waste component because such characteristic or component is not expected to significantly influence the containment of the waste in the disposal system.

A Waste Characterization Peer Review (WCPR) Plan (see CCA Appendix PEER) was prepared and approved in accordance with the requirements of TP 10.5. The DOE convened a four-member peer review panel, in accordance with the guidance of NUREG-1297, to perform the review. The panel members were:

- Duane C. Hrncir (Panel Chairman), University of Texas, Dallas;
- Evaristo J. Bonano, Beta Corporation International;
- James F. Bresson, Informatics Corporation; and
- Patricia J. Robinson, Energy, Inc.

See CCA Appendix PEER for the qualifications of the panel.

9.3.2.1 General Results

The following excerpts are from the WCPR report (CCA Appendix PEER). They address areas that the panel considered adequate.

- Radionuclide Inventory and Release Limits. The analysis performed in estimating the parameters needed to establish the radionuclide inventory and release limits for estimating the CCDF was very thorough and systematic. This is a solid piece of work.
- Solubility. The median values for actinide solubility are reasonable.
- Colloids. The experiments dealing with colloids in the repository were well done.
- Production of Gas. (Appendix WCA) adequately identifies the major issues of gas generation in the waste.
- Permeability. There are experimental data to support the conclusions about permeability discussed in (Appendix WCA). The panel concurs with the conclusions.
- Heat Generation. The analyses presented in (Appendix WCA) concerning heat generation are well done. The conclusion that this characteristic will have a negligible effect on performance is justified.
- Metals. The assumption that low valent metals in the repository will maintain a reducing atmosphere in the repository is substantiated by experimental data.
- Cellulosics. Cellulosics will be microbially degraded to carbon dioxide and CH_4. They also may provide a source of humic colloids. Treatment of these issues by (Appendix WCA) has been discussed in the appropriate sections above.
- Water and Other Liquids. The panel agrees with the findings in (Appendix WCA). Water in the waste is not an issue in repository performance.
- Exclusion of Waste. (1) The analysis performed to support the exclusion of radionuclides is methodical, complete and well done. (2) The exclusion of hazardous wastes is justified.

9.3.2.2 Waste Characterization Peer Review Panel Concerns

The WCPR panel concluded that several areas they examined were inadequate. The WCPR panel's concerns, the DOE's response to the panel's concerns, and the panel's responses are briefly described below. For details of the DOE and the panel's interactions, see CCA Appendix PEER.

9.3.2.2.1 Peer Review Panel Concern – Radionuclide Inventory and Release Limits

> The analysis used to determine the heterogeneous source term for the intrusion scenario was not clearly presented in CCA Appendix WCA, resulting in an inability to judge its validity and degree of conservation.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.2 Peer Review Panel Concern – Solubility; First Concern

> The median values for actinide solubility are reasonable, but the uncertainty ranges about the median are too low and inconsistent with earlier results from the expert judgment panel study.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.3 Peer Review Panel Concern – Solubility; Second Concern

> The issue of actinide solubility is not adequately addressed in CCA Appendix WCA because the controlling assumption concerning MgO chemistry in the repository has no experimental data to support it.

After consideration of the DOE response, the panel concluded that the DOE understood the issues; however, the panel determined that the response did not reasonably address their concern. See CCA Section 9.3.2.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.2.2.4 Peer Review Panel Concern – Colloids

> The uncertainty given for the colloid actinide source term is not adequate for purposes of PA calculations because the number of experiments performed does not generate meaningful statistical samples from which an uncertainty could be adequately calculated.

After consideration of the DOE response, the panel concluded that the DOE understood the issues and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.5 Peer Review Panel Concern – Production of Gas; First Concern

> The issue of the reaction of carbon dioxide with the MgO backfill is not adequately resolved in CCA Appendix WCA, because of a lack of experimental data which demonstrated that this chemistry occurs under conditions anticipated in the repository.

After consideration of the DOE response, the panel concluded that the DOE understood the issue; however, the panel concluded that the response did not reasonably address their concern. See CCA Section 9.3.2.2 for details of the DOE response, including the discussion "Department of Energy Technical Position versus Panel Issue."

9.3.2.2.6 Peer Review Panel Concerns – Production of Gas; Second and Third Concerns

> CCA Appendix WCA does not adequately address the fate of microbially generated CH_4.

> The treatment of gas generation in CCA Appendix WCA is generally well done. However, the Appendix does not deal with the disposition of the generated CH_4. The gas

> will be produced on a mole per mole basis with carbon dioxide and yet there is no mention of its fate in the repository.

After consideration of the DOE response, the panel concluded that the DOE understood the issues and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.7 Peer Review Panel Concern – Compressibility

> Appendix WCA references studies describing the analysis of waste compressibility; however, it fails to provide any discussion of the results of these studies.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.8 Peer Review Panel Concern – Strength

> CCA Appendix WCA references a study on waste strength, but fails to discuss the results of this study in the context of its impact on disposal system performance.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.9 Peer Review Panel Concern – Porosity

> There are conflicting statements in CCA Appendix WCA concerning the importance of porosity to the performance of the repository. As a result, the panel was unable to evaluate the treatment of this parameter.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.10 Peer Review Panel Concern – Metals

> The position taken in CCA Appendix WCA concerning the uptake of organic ligands by the transition metals is not defensible due to lack of experimental data. It is not correct to apply results from experiments performed in low ionic strength solutions to WIPP brines.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.2.2.11 Peer Review Panel Concern – Chelating Agents

> The position that transition metals will react with the organic ligands in the waste to render them unavailable for reaction with actinides should be justified with experiments done in high ionic strength brines.

After consideration of the DOE response, the panel concluded that the DOE understood the issue and provided a reasonable response. See CCA Section 9.3.2.2 for details of the DOE response.

9.3.3 Engineered Alternatives Cost/Benefit Study Peer Review

Per the criteria of 40 CFR § 194.27(a)(3), a compliance application shall include documentation of a peer review that was conducted for "(e)ngineered barrier evaluation as required in §194.44." 40 CFR § 194.44(b) states

> In selecting any engineered barrier (s) for the disposal system, the Department shall evaluate the benefit and detriment of engineered barrier alternatives, including but not limited to: Cementation, shredding, supercompaction, incineration, vitrification, improved waste canisters, grout and bentonite backfill, melting of metals, alternative configurations of waste placement in the disposal system, and alternative disposal system dimensions. The results of this evaluation shall be included in any compliance application and shall be used to justify the selection and rejection of each engineered barrier evaluated.

In September 1989, DOE established the Engineered Alternatives Task Force (EATF) to identify and screen potential engineered alternatives (EAs) with respect to both effectiveness and feasibility of implementation in addressing concerns about gas generation and human intrusion. EAs are engineered barriers, waste modifications, facility modifications, process changes, or any other approach that enhances disposal system performance or reduces uncertainty in the predictions of disposal system performance.

The EATF, in turn, chartered an Engineered Alternatives Multidisciplinary Panel that qualitatively screened an initial 64 alternatives to 36. The EATF then combined these candidates into 14 logically consistent and potentially actionable EAs. These 14 candidates, plus a base case, were evaluated with respect to relative effectiveness and feasibility in addressing gas generation and inadvertent human intrusion impacts. The EATF issued its final report in July 1991 (DOE 1991). A subsequent peer review of the EATF Report is documented below (Section 9.4.4).

The DOE prepared the Engineered Alternatives Cost/Benefit Study (EACBS) Final Report (DOE 1995b and CCA Appendix BARRIERS, Attachment EBS) in 1995. The EACBS Report includes a qualitative assessment of estimated costs, potential risks and benefits, and relative repository performance impacts resulting from the implementation of EAs .

The EACBS differs from the 1991 EATF in two fundamental ways. First, in the EACBS, EAs are assessed against 8 factors specified in 40 CFR § 194.44(c)(1) that provide the data and information for use in selecting or rejecting an EA. The eight factors are:

1. Long-term repository performance,
2. Uncertainty in compliance assessment,
3. Impact on public and worker exposure,
4. Impact on waste removal,
5. Transportation risk,
6. Public confidence,

7. Impact on system cost and schedule, and
8. Impact on other disposal systems.

Second, the 1991 EATF study was aimed at identifying alternatives which, if needed, would improve disposal system performance to the point where compliance with quantifiable standards was achieved. The EACBS begins with the assumption that compliance is achieved and the comparison of alternatives is to assist future decision making should a need for additional EAs be identified.

An EACBS Peer Review Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of TP 10.5. The plan describes the peer review process used to ensure a sound technical basis for the selection or rejection of EAs should it be determined that additional engineered barriers are needed to satisfy the requirements of 40 CFR Part 191 Subparts B and C.

An independent peer review committee was assembled by the Waste-Management Education and Research Consortium (WERC) to provide the DOE with a review of the EACBS Final Report. The peer review was conducted in 1996, in a manner consistent with NUREG-1297 (NRC 1988) guidance and the requirements of TP 10.5 (DOE 1996c).

The purpose of the EACBS peer review was to assess the validity of the assumptions and the technical approach used in the EACBS and evaluate the adequacy of the work. The peer panel review focused on determining the reasonableness of the report's conclusions.

In accordance with the provisions of TP 10.5, a panel was selected. The nine-member panel was composed of the following individuals:

- Rohinton K. Bhada (Chairman), New Mexico State University;
- Catherine T. Aimone-Martin, New Mexico Institute of Mining and Technology;
- Arturo Duran, Environmental Consulting and Engineering;
- Douglass J. Kuhns, Lockheed-Martin Idaho Technologies Corporation;
- Cindy R. Lewis, Parsons Engineering Science, Inc.;
- James D. Navratil, Rust Federal Services;
- Jamal Rostami, Earth Mechanics Institute;
- Dennis M. Smith, Technical & Management Systems and Services, Inc.; and
- Krishan K. Wahi, Geological Repository Assessment Methodologies, Inc.

See CCA Chapter 9, Section 9.3.3, for the panel members' qualifications and other details regarding the EACB peer review.

Panel members have established academic qualifications, as well as substantial relevant experience, and are independent of the WIPP project. Additional information regarding the technical qualifications of the panel members is provided in the final peer review report (see CCA Appendix PEER). A letter from the Peer Review Manager regarding the verification of independence for panel members is also presented in CCA Appendix PEER (additional information regarding the independence of the panelists is available in the CBFO Record Center.) All technical disciplines needed to perform the review were represented.

After orientation and training, as required by TP 10.5, the panel was briefed by the EACBS report authors and DOE staff. To review the large amount of information provided in the EACBS and supporting documentation, the peer panel divided itself into three subcommittees to address specific factors of the study. The subcommittees were formed on the basis of the expertise that was most appropriate for each set of factors. Eventually, all subcommittee findings were reviewed by the entire panel.

9.3.3.1 General Results

Following its review, the panel prepared a final report on July 10, 1996. The results of the EACBS peer review evaluation are summarized in Table 9-2 and a copy of the complete report is provided in CCA Appendix PEER. The following conclusions are presented in the final report:

- the information presented within the EACBS is of high quality,
- the approach taken is valid,
- the conclusions drawn are reasonable, and
- the analysis was conducted in accordance with 40 CFR § 194.44 criteria.

The EACBS panel report also identifies several findings/concerns/issues. The DOE developed a response to the issues identified in the panel report. The panel’s concerns and the DOE responses are discussed in the following sections.

9.3.3.2 Engineered Alternatives Cost/Benefit Study Peer Review Panel Concerns

The DOE conducted an evaluation to assess the relative benefit and associated cost of various EAs for the disposal system. The analytical methodology and final results of the EACBS were critically reviewed for technical merit, adequacy, and accuracy of results by a team of outside experts.

Table 9-2. Summary of the Peer Review of the EACBS Evaluation Factors and Criteria

Engineered Alternatives Evaluation Factors	A. Adequacy of Requirements and Criteria	B. Validity of Assumptions	C. Alternative Interpretations	D. Uncertainty of Results and Consequences if Wrong	E. Appropriateness and Limitations of Methodology and Procedures	F. Adequacy of Application	G. Accuracy of Calculations	H. Validity of Conclusions
Evaluation of the EA Screening Process	Generally considered to be adequate, although some other potential EAs could have been added.	Evaluation was qualitative and was to assess assurance, not compliance. This assumption was prescribed by law and was therefore considered valid.	None.	The screening process was conservative in nature and was thus more inclusive than exclusive.	The screening process was considered to be appropriate. A better description of the process would have enhanced the report.	The sequence of comparing, scoring, prioritizing, etc. was adequate to achieve the results.	The use of algorithms and professional judgement were deemed appropriate.	The final list of EAs selected for further analysis was reasonable.
1. Long Term Repository Performance	Adequate	Broad Level: Appropriate. Detailed Level: Intrusion scenarios assumed to occur at 5,000 years; and actinide solubility assumptions were conservative. Broad Level: Appropriate; Detailed Level: Uncertainty in creep parameters was not considered. Differences in creep closure estimates could affect the quantity and rates of release; early intrusion could result in significantly different releases; and EAs with plasma processing or clay backfill were not credited with enhanced Pu immobilization.	Different creep closure models or model coefficients may affect the relative benefits of EAs; and the effects of future mining nearby could have been considered as an additional human intrusion scenario.	Uncertainty will result due to the uncertainty of input parameters; however, no severe consequences if wrong; conservative parameter estimates were used.	Use of the Design Analysis Model (DAM) model to predict performance was appropriate; however, important advances in creep modeling were not used. Model did not (and cannot) consider stratigraphy (e.g., anhydrite layers) in the mechanical response calculations.	Compressive strengths of waste/backfill EAs is misleading; and intrusion before creep closure not adequately analyzed.	Creep rate calculations checked and qualitatively agree.	Effectiveness of some EAs may have been under-estimated due to simultaneous consideration of pre-closure and post-closure risks.

Table 9-2. Summary of the Peer Review of the EACBS Evaluation Factors and Criteria — Continued

Engineered Alternatives Evaluation Factors	A. Adequacy of Requirements and Criteria	B. Validity of Assumptions	C. Alternative Interpretations	D. Uncertainty of Results and Consequences if Wrong	E. Appropriateness and Limitations of Methodology and Procedures	F. Adequacy of Application	G. Accuracy of Calculations	H. Validity of Conclusions
2. Uncertainty in Compliance Assessment				Relative nature of analysis allows meaningful conclusions to be drawn. Discussion of uncertainty in the results does not fully reflect the uncertainty analysis that was in fact carried out.		Methods used are completely applicable for comparative screening process		
3. Worker and Public Risk	Adequate	Risk assumptions are conservative, conventional, and adequate for the work performed.	None.	Uncertainties err on the side of safety and risks are likely overstated.	Methodology did not account for risks inherent in current waste handling methods. For example, relative risks could have been different for these EAs having long development/ processing time.	Methods are applicable for the comparative screening process.	Calculations are reasonable and consistent.	Risk conclusions for CH-TRU waste appear valid. Risk conclusions for RH-TRU waste are absent.
4. Impact on Waste Removal	200-year period for waste removal requires justification; different time frames have a major impact on the methods used for retrieval.	Assumed excavation technology is appropriate, but the data used in the calculations is not state of the art. For long term retrieval, assumptions and methodology used for mining rate and time estimates are correct; quantitative studies are needed. Short-term retrieval method, rate, and schedule not	Alternative methods for recovery based on different time frames could have been performed.	Uncertainty associated with the compressive strength of the EAs is not critical to the relative comparison of EAs. The waste is removable with today's technology and the decisions made based on the EACBS are not irreversible.	Methodology was appropriate to estimate time required for long-term removal; however, some of the assumptions, data, and terminology were not suitable for the application.	Time of waste removal was not adequately addressed.	Overall, calculations could not be checked for accuracy; there is no reference to machine type, specifications, and utilization.	Although the quantitative results of the analysis can not be directly used for assessment of the EAs, the general conclusions based on a qualitative comparison with the baseline are valid and

Table 9-2. Summary of the Peer Review of the EACBS Evaluation Factors and Criteria — Continued

Engineered Alternatives Evaluation Factors	A. Adequacy of Requirements and Criteria	B. Validity of Assumptions	C. Alternative Interpretations	D. Uncertainty of Results and Consequences if Wrong	E. Appropriateness and Limitations of Methodology and Procedures	F. Adequacy of Application	G. Accuracy of Calculations	H. Validity of Conclusions
		addressed.						acceptable for long-term removal. Consideration of short-term removal could change the results.
5. Transportation Risk	Adequate	Risk analysis assumes 20 year active life, yet the WIPP operational window is for 33 to 35 years. Transportation is by truck only; no explanation why rail is not evaluated. Overall, however, risk assumptions are conservative, reasonable and well within contemporary transportation risk analysis.	There is no reasonable alternative interpretation.	Population densities will be different if the period of transportation and disposal is greater than 20 years. An added risk could occur for those EAs that have a longer time frame.	The methodologies were considered to be generally appropriate. Limitations include addressing only CH-TRU waste, a “bounding” accident not being evaluated, and lack of justification for selected values. The limitations should not compromise the EA evaluation so long as the 20 versus 35 year issue is recognized.	Methods used are applicable for comparative screening process.	Calculations appear to be reasonable and consistent with the methodology.	The conclusions drawn for purposes of a qualitative comparison of the transportation risks of the various EAs appears valid.
6. Public Confidence in the Performance of the Disposal System	Adequate	Assumptions regarding the public’s concerns as to content, categorization, timeliness, and affected in-state population are	Slightly different interpretations are possible, but would not affect the	Uncertainty is low regarding the public’s position on the EAs and slight misinterpretations are not considered	The methodology used to assess public confidence was appropriate. A limitation is the lack of	Application of the methodology was considered proper.	Categorization of public comments was checked and determined to be relatively	The conclusions appear appropriate.

Table 9-2. Summary of the Peer Review of the EACBS Evaluation Factors and Criteria — Continued

Engineered Alternatives Evaluation Factors	A. Adequacy of Requirements and Criteria	B. Validity of Assumptions	C. Alternative Interpretations	D. Uncertainty of Results and Consequences if Wrong	E. Appropriateness and Limitations of Methodology and Procedures	F. Adequacy of Application	G. Accuracy of Calculations	H. Validity of Conclusions
		reasonable. Although out-of-state populations were not addressed, this is not considered to be a major deficiency.	conclusions of the study.	serious.	opportunity for out of state public comment.		accurate with only minor discrepancies.	
7. System Cost and Schedule	Adequate	Cost and schedule assumptions are considered to be valid with uncertainty of approximately 30 percent associated with the uncertainty of the waste inventories.	A few alternate interpretations may originate from the guidance documents. However, they would have little effect on the study's results.	The estimated costs and schedules were reasonable.	The methodology for cost and schedule evaluation is considered appropriate.	Methodologies were appropriately applied.	Spot checks determined that calculations were performed according to accepted methods and procedures.	In general, the conclusions are valid.
8. Impact on Other Disposal Systems	Adequate	The assumptions of waste type and volume have uncertainties associated with them that may impact other disposal systems. The assumptions used appear reasonable.	The uncertainties associated with waste volume can be interpreted in different ways. Some interpretations will result in higher volumes while others will result in lower volumes.	Uncertainty of results are +10 percent to 25 percent based on waste volume uncertainty. No serious negative consequences should occur because of this uncertainty.	Procedures used are technically defensible. A limitation of the methodology is the reliance on the accuracy of waste volume.	The techniques used were adequate to meet the intended goal.	The basis of calculations was not provided in the EACBS; however, using reasonable assumptions, data spot checks were found to be accurate.	The conclusions reached are valid and support the end use of the report.

The EACBS panel expressed several concerns regarding the EACBS. Details of the EACBS panel's concerns and the DOE's response to the panel's concerns (Response to Issue) are presented in CCA Appendix PEER and CCA Section 9.3.3.2. The panel was asked to review the DOE responses and determine whether they agreed with the responses. The panel's reaction to the responses are also provided in CCA Appendix PEER (Peer Reviewer Consideration of Response). In those instances where panel members disagreed, from a technical-based perspective, with the DOE response, the DOE developed additional information that describes the justification for its final technical position on the concern (DOE Technical Position versus Panel Issue). A summary of the panel's concerns and the panel's reaction to the DOE responses are provided below. For details, see CCA Appendix PEER.

9.3.3.2.1 First Peer Review Panel Concern – Results of the Engineered Alternatives Identification/Screening Process

> Clarification is needed in the text of the report on the steps involved in the identification/screening process, including steps that occurred after the Engineered Alternatives Task Force performed their initial evaluation. Better define what is meant by "screening," "optimization," and "prioritization." Clearly state the criteria used for each stage of the process.

The DOE stated that it understood the confusion surrounding these terms, particularly in light of the multiplicity of the agencies and organizations that have expressed interest in how EAs should be applied to the WIPP. In this application, DOE had attempted to use these terms in a fashion consistent with the EPA's usage in 40 CFR Part 194 and the Compliance Application Guidance (CAG) (EPA 1996c). The three processes are documented in the EACBS. The specifics of the screening process and original prioritization are found in Appendix D. The optimization process is briefly described in Appendix D; this process included management decisions not defined in the report.

Four panel members commented on the DOE response to this concern. Two members agreed with the response and one disagreed. The fourth panelist, although agreeing that the information in the response was adequate, believed this information should be provided in the main part of the EACBS.

The DOE has clarified the process in Section 7.4.3.1 of the CCA, which includes a description of the DOE Management Assessment used to determine the final 18 EA used in the analysis.

9.3.3.2.2 Second Peer Review Panel Concern – Results of the Engineered Alternatives Identification/Screening Process

> Some concern was expressed that the screening process was conducted independent of a consideration of the eight factors used in evaluating the EAs. If the screening process and evaluation of EAs according to the eight factors had been iterative, the list of EAs analyzed as well as the results of both the screening process and the evaluation of the EAs may have been different. However, this would probably be an endless process of iterations and not justified because of cost and time involved.

In response, the DOE stated that to ensure a reasonable menu of alternatives for potential selection of engineered barriers, the DOE elected to separate the screening process from the actual factor analyses. The key screening criteria to select EAs for detailed factor analysis was therefore the impact on improving long-term performance, with additional concern given to technological and regulatory feasibility of implementation. The selected alternatives were then evaluated with respect to the eight factors. Factors such as waste retrieval or public perception were not considered in the selection criteria because these factors are not related to compliance with 40 CFR Part 191 Subparts B and C.

Three panel members commented on the response. One panelist agreed with the response as written and one other disagreed. The third commenter agreed with the response but believed that the DOE should make a stronger case that the EACBS considered the breadth of plausible alternatives.

The DOE's technical position is that the DOE developed a screening process that used a qualitative assessment of the potential benefits on the WIPP disposal system. Good engineering practices were used in this assessment. A pure quantitative rating could not be justified because it would require a complete analysis of each EA by all eight factors. The intent of the screening process was to identify EAs with the highest potential to benefit the disposal system and further analyze their impacts within the multifactor analysis.

9.3.3.2.3 Third Peer Review Panel Concern – Results of the Engineered Alternatives Identification/Screening Process

> Remote-handled waste was not considered. This issue may have implications to the compliance application.

In response, the DOE stated that RH-TRU waste constitutes a maximum of five percent of the inventory by volume. This material is practically identical to CH-TRU waste except that it is contaminated with short-lived beta-gamma emitters, as well as the long-lived actinides present in CH-TRU waste. There is therefore no need to consider RH-TRU waste separately from a long-term performance standpoint. There may have been some differences in the treatment costs for the RH-TRU fraction because of the possible need for a greater degree of shielding, and there may have been additional worker risks involved because of the penetrating radiation. The Engineered Alternatives Screening Working Group concluded, therefore, that the limited volume of RH-TRU waste did not justify separate consideration of this small fraction of the inventory.

The only panel member who commented on the response agreed, in part, with the response; however, the panelist suggested that, for completeness, a factor approach be used that could weigh the risk and cost of handling RH-TRU waste into each EA under evaluation.

The DOE's position is that because the RH-TRU waste is a small percentage of the total WIPP waste inventory, is limited by the Land Withdrawal Area, and will decay to CH-TRU waste levels in a relatively short time, the DOE believes that RH-TRU wastes need not be considered separately in the EACBS.

9.3.3.2.4 Peer Review Concern – Evaluation of Factors 1 and 2: Impacts on Long-Term Repository Performance and Uncertainty in Compliance Assessment

These factors focused primarily on the analyses performed with the DAM computer simulation program. This program was used to predict the future performance of the repository with different EAs given three different human intrusion scenarios. Values for several parameters are required as input to the model. Many input parameters were treated as being uncertain; that is, ranges and distributions were assigned to such parameters. Other parameters were given constant (single point) values. The panel members checked many of these parameters, as well as QA documentation for the computer simulation itself. No major discrepancies or errors were noted. It was noted by the panel members that much of the information used in the model was selected to be consistent with the PA conducted by SNL. The DAM was chosen to determine relative repository performance because it parallels SNL's PA work in a less complex manner, allowing various changes to the inputs to be run quickly on a PC format. For details on a number of subissues under this category, see CCA Chapter 9.0 and CCA Appendix PEER.

9.3.3.2.5 First Peer Review Panel Concern – Evaluation of Factor 3: Impact of Engineered Alternatives on Worker and Public Risk

> An evaluation of the risks associated with the processing of remote-handled (RH) waste is absent. It would be helpful to include a discussion of the possible relative comparison between the risk associated with CH and RH wastes. For example, one can draw conclusions based on radionuclide difference, radionuclide mobility, potential for release, transport mechanisms, and exposure scenarios associated with both waste processing and long-term performance.

The DOE responded that the inventory of RH-TRU waste was combined with the CH-TRU waste and was not considered separately in the EACBS. RH-TRU waste is limited by statute to comprise no more than five percent by volume of the total WIPP waste inventory. This material is practically identical to CH-TRU waste, except that it is contaminated with short-lived beta-gamma emitters as well as the long-lived actinides present in CH-TRU waste. These beta-gamma emitters will rapidly decay in the 100-year postclosure period during active institutional control. Therefore, there is no need to consider RH-TRU waste separately from a long-term performance standpoint.

The only panel member who commented on this response partially agreed with the DOE response. That panelist made the same comment as for the RH-TRU waste concern discussed in Section 9.3.3.2.3.

The DOE's position is that because the inventory of RH-TRU wastes is a small percentage of the total WIPP waste inventory, is limited by the Land Withdrawal Area, and will decay to CH-TRU waste levels in a relatively short time period, the DOE believes that RH-TRU wastes need not be considered separately in the EACBS.

9.3.3.2.6 Second Peer Review Panel Concern – Evaluation of Factor 3: Impact of Engineered Alternatives on Worker and Public Risk

> Many of the assumptions used in assessing worker and public risk appear to be borrowed from the Environmental Management Programmatic Environmental Impact Statement (EMPEIS). While these assumptions may be valid, additional discussion of them in the text of the EACBS would provide further clarification.

The DOE responded that many of the assumptions and initial analysis parameter values were, as the panel has noted, taken from the EMPEIS. This consistency was important to keep the EACBS risk analysis consistent with important aspects of other related DOE risk evaluations nationwide. The entire suite of WIPP National Environmental Policy Act (NEPA) documents is available for review in several locations. The DOE did not see the need to discuss these assumptions in any greater detail within the EACBS.

The only panel member who commented on this response agreed with the DOE response.

9.3.3.2.7 Third Peer Review Panel Concern – Evaluation of Factor 3: Impact of Engineered Alternatives on Worker and Public Risk

> Additional risks posed by allowing the waste to remain above ground for longer time periods necessitated by some of the EAs were not evaluated. This could underestimate risks associated with those EAs.

The DOE responded that the purpose of the EACBS study was to determine relative risks from various TRU waste processing and disposal alternatives, and did not directly include waste storage impacts, as noted. It is true that in some cases waste would be stored aboveground for a longer time for some of the EAs, particularly when a given treatment process has not yet been fully developed for TRU waste. However, ultimately, a long-term disposal decision would be needed. The scope of the EACBS was to look at alternatives to support the disposal decision. It is assumed that the waste containers would be stored for an additional time period within the expected lifetime of the container, and therefore no repackaging related risks would be included. It is further assumed that workers will continue to limit their exposure to stored waste containers in accordance with the as low as reasonably achievable (ALARA) policy. Therefore, the loss of resolution did not affect the DOE decisions in important ways.

The only panel member who commented on this response agreed with the DOE response.

9.3.3.2.8 Peer Review Panel Concern – Evaluation of Factor 4: Waste Removal Impact

The evaluation of Factor 4 was conducted in the context of 40 CFR § 194.44, assuming that the removal of the emplaced waste and backfill (after the regulatory closure) is possible. The factor considers the impact of EAs on waste removal after 200 years with no justification. The methodology used and the conclusions made based on a qualitative comparison using the volume and the time required for removal were acceptable to the panel. However, the panel made some comments with respect to this factor. See CCA Appendix PEER for the details of these comments and their resolution.

9.3.3.2.9 Peer Review Panel Concern – Evaluation of Factor 5: Impact of Engineered Alternatives on Transportation Risk

A number of procedural-type questions were raised by the panel related to the impact of EAs on transportation risk. DOE provided satisfactory explanations for these questions and no outstanding issues remained. See CCA Chapter 9 and CCA Appendix PEER for details.

9.3.3.2.10 Evaluation of Factor 6: Impact of Engineered Alternatives on Public Confidence

The peer review panel did not find any particular areas of concern with the public confidence evaluation, and felt that the methods used and conclusions reached were appropriate and reasonable. There are no specific comments or areas of concern in need of response.

9.3.3.2.11 Evaluation of Factor 7: Total System Cost and Schedule Estimates

The peer review panel found no significant flaws in the cost and schedule analysis. The panel agreed that the development of cost and schedule estimates was reasonable, appropriate, and defensible. There were no specific comments or areas of concern in need of response for this factor.

9.3.3.2.12 Peer Review Panel Concern – Evaluation of Factor 8: Impact on Other Waste Disposal Programs

The peer review panel concluded that the analysis for impacts to other waste disposal programs was conducted using the best available information. However, they felt that the evaluation should be updated as more recent and accurate data become available to ensure adequate facilities and resources are available for disposal. DOE provided additional details that satisfied the panel. See CCA Chapter 9 and CCA Appendix PEER.

9.3.4 Engineered Systems Data Qualification Peer Review

An Engineered Systems Peer Review (ESPR) Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of TP 10.5. The plan describes the peer review process used to ensure that the data used in the models describing engineered systems for rock mechanics and shaft/borehole seals in the PA are qualified to demonstrate compliance.

The DOE used an Independent Review Team (IRT) to carefully review the existing data that was necessary to support the PA. Much of the existing data were qualified because the IRT determined that the QA program in place at the time of its collection was equivalent to American Society of Mechanical Engineers (ASME) nuclear quality assurance (NQA) requirements. It was determined, however, that some data used to describe engineered systems could not be qualified in that manner.

40 CFR § 194.22(b) states that:

> Any compliance application shall include information which demonstrates that data and information collected prior to the implementation of the quality assurance program required pursuant to paragraph (a)(1) of this section have been qualified in accordance with an alternate methodology, approved by the administrator or the administrator's authorized representative, that

> employs one or more of the following methods: peer review, conducted in a manner that is compatible with NUREG-1297....

The purpose of the ESPR was to seek qualification of scientific data by systematically reviewing parameters and subsystems used in the models describing engineered systems. The conceptual models used in the PA of the engineered systems include components of

- disposal room geometry,
- creep closure,
- repository fluid flow,
- shafts and shaft seals, and
- DRZ.

The review was conducted by four panel members. The panel members and their affiliation were

- Dermot Ross-Brown (Chairman), Independent Consultant;
- John Gibbons, Independent Consultant;
- Darrell Porter, Science Applications International Corporation; and
- John Schatz, Independent Consultant.

See CCA Chapter 9 and CCA Appendix PEER for details of the qualifications of the panel members.

The panel performed an in-depth critique of assumptions, alternate interpretations, methodology and acceptance criteria employed, and of conclusions in the original work. According to the "Description of Work Performed" in their final report, the panel members considered:

- sources of the parameters and data: for example, professional judgment, published source material, field tests, laboratory experiments, etc.;
- appropriateness of the parameters and data for their intended use; and
- assumptions, calculations, extrapolations interpretations, methods, appropriateness, validity, sensitivities, and conclusions pertinent to the parameters and data used as input to the WIPP PA.

The data considered by the panel supported the models describing engineered systems and were used to derive parameter values that are incorporated into the models. In some instances, parameters were consolidated into parameter groups.

Fourteen parameters (several of which were actually groups of closely related parameters) were evaluated by the panel. The panel qualified seven of the parameters and two of the parameter groups (properties of halite and anhydrite, and data on final porosity surface). In the panel's opinion, minor changes needed to be made to two of the parameters (pore volume compressibility of Salado Mass Concrete (SMC) and permeability of consolidated waste), and further analysis by SNL was needed on two other of the parameter groups (permeability of crushed salt and the strength of the waste for spalling (blowout) releases. The panel concurred with SNL's general treatment of the remaining parameter (general treatment of the DRZ). Table 9-3 lists the parameters reviewed by the panel and summarizes the panel's conclusions regarding their adequacy.

Table 9-3. Summary of Qualification Status of Parameters, as a Result of the Engineered Systems Peer Review

Subsystem	Parameter Name	Qualification Status of Parameters
Shaft/shaft Seal	Porosity of SMC	Qualified
	Pore Volume Compressibility of SMC	Minor change to value suggested [1]
	Bulk Modulus of Crushed Salt	Qualified
	Permeability of Crushed Salt	Requires further analysis by SNL[1]
	Permeability of SMC	Qualified
	Permeability of Compacted Clay	Qualified
Disposal Room/Rock Mechanics	Initial Density of Waste	Qualified
	Mechanical Properties of Waste	Qualified
	Initial Water Content of Waste	Qualified
	Permeability of Consolidated Waste	Minor change to value suggested [1]
	Strength of Waste for "Blowout"	Insufficient data to qualify [1]
	Properties of Halite and Anhydrite	Qualified, based on limited review[2]
	Data on Final Porosity Surface	Qualified, based on limited review[2]
DRZ	Characterization of DRZ	Concepts qualified

[1] The panel subsequently determined, on the basis of additional input from DOE, that DOE responses had reasonably addressed their concerns.
[2] The panel chose to consider these parameters from an overview approach; however, the panel was able to qualify these parameters.

Initially, the ESPR panel failed to qualify four of the parameters (or parameter groups) they reviewed. Where appropriate, the DOE interpreted the ESPR panel's concern and in all four cases developed a WIPP project response. The ESPR panel's concerns (in italics), the DOE's interpretations of the panel's concerns (Statement of Issue), where appropriate, and their responses (Response to Issue) are provided below. The panel then reviewed the response to determine whether the DOE understood the issue and provided a reasonable response (Peer Reviewer Consideration of Response).

The DOE responses were provided to the panel as individual memoranda. For incorporation into this application, the responses were edited to remove the memorandum format, consolidate references, replace first-person text, insert cross-references where appropriate, and correct typographical errors. Substantive technical content of the responses was not changed.

Based on the additional information the DOE provided in response to the panel's concerns, the panel subsequently concluded that the DOE had reasonably addressed their concerns for all the parameters and parameter groups. The data used to derive the parameters and parameter groups that were reviewed by the ESPR panel were therefore qualified per 40 CFR § 194.22(b).

At the completion of the review, the panel prepared a documented summary of its work and an evaluation of the selected parameters reviewed by the panel. A copy of the Engineered Systems Data Qualification Peer Review Report, dated July 1996, is provided in CCA Appendix PEER. For detailed discussion of the panel's work and the interaction between the panel and the DOE technical staff, see CCA Chapter 9. Since the panel concluded that the DOE had reasonably addressed their concerns for all the parameters and parameter groups, the work of the panel is not further discussed here.

9.3.5 Natural Barriers Data Qualification Peer Review

The DOE used an IRT to carefully review the existing data that was necessary to support the PA. Much of the existing data was qualified because the IRT determined that the QA program in place at the time of its collection was equivalent to ASME NQA requirements. It was determined, however, that some data used to describe natural barrier subsystems could not be qualified in that manner.

A Natural Barriers Peer Review (NBPR) Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of TP 10.5. The purpose of the plan was to describe the NBPR process. The NBPR panel evaluated existing data and information that form the basis of the parameter values used in the mathematical expression of conceptual models for the natural barriers subsystems in the WIPP. The parameters selected for evaluation were those that had not previously been fully qualified for use in PA.

The conceptual models used in the PA of the natural barriers subsystem include components of: (1) disposal system geometry; (2) Culebra model geometry; (3) repository fluid flow; (4) Salado; (5) impure halite; (6) Salado interbeds; (7) DRZ; (8) actinide transport (Salado); (9) units above the Salado; (10) dissolved Actinides (Culebra); (11) colloidal actinides (Culebra); (12) exploration boreholes; (13) cuttings and cavings; (14) spallings; (15) DBR; (16) Castile and brine reservoir; (17) multiple intrusions; and (18) climate changes.

A peer review panel, consisting of the following six members, was convened to undertake the work:

- Darrel E. Dunn (Chairman), Independent Consultant;
- Florie Caporuscio, LANL;
- Paul L. Cloke, Independent Consultant;
- David A. Sommers, Independent Consultant;
- Charles Wilson, Independent Consultant; and

- Chuan-Mian Zhang, Woodward-Clyde Federal Services.

See CCA Chapter 9 and CCA Appendix PEER for details of the panel members' qualifications.

Upon completion of the orientation and training required by TP 10.5, the panel was provided 32 parameter packages for their review. In addition, technical reports and documents were obtained by the panel from the SNL waste management library and records center to supplement the information in the parameter packages. Both formal and informal technical discussions were held with SNL principal investigators to assist the panel members to more fully understand the concepts and parameter derivation and application in the PA.

The NBPR panel evaluated 142 parameters against the eight review criteria cited in NUREG-1297 (NRC 1988). The parameters were organized into 32 parameter packages, some of which contained more than one parameter. The parameter packages were grouped into three subsystems; Salado, Castile, and units above the Salado, to facilitate the review process.

In some subsystems, individual parameter values were evaluated and a determination made of their adequacy as used in the WIPP PA program. In others, sets of parameters were evaluated to determine their collective contribution to a combined parameter value. The panel performed an in-depth critique of assumptions, alternate interpretations, methodology and acceptance criteria employed, and the conclusions drawn in the original work. In evaluating the existing unqualified data, the peer review panel members considered the following:

- The source of the parameters and data (for example, professional judgment, published source material, field tests, laboratory experiments, etc.);

- The appropriateness of the parameters and data for their intended use; and

- The assumptions, calculations, extrapolations, interpretations, methods, appropriateness, validity, sensitivities, and conclusions pertinent to the parameters and data used as input to the WIPP PA.

At the conclusion of its review, the panel developed a final report (August 1996). A copy of the NBPR Report is provided in CCA Appendix PEER.

Table 9-4 provides a listing of the 32 parameter packages, the appropriate subsystem, the number of parameters in the specific packages, and the qualification status of each as determined by the peer review panel. The panel concluded that 31 of the parameter packages were fully qualified. Therefore, the data supporting those parameters are qualified per 40 CFR § 194.22(b). The panel had a concern about one of the 21 data packages for the Culebra transmissivity parameter at well P-18.

Table 9-4. Summary of Parameters Reviewed and Qualification Status

Parameter Package	Subsystem	Number of Parameters	Qualification of Parameter
DRZ Compressibility	Salado	2	Adequate
Undisturbed Halite Pore Pressure		1	Adequate
Undisturbed Halite Compressibility		1	Adequate
Effective Halite Porosity		1	Adequate
Undisturbed Halite Permeability		3	Adequate
Undisturbed Anhydrite Pressure		2	Adequate
Undisturbed Anhydrite Rock Compressibility		3	Adequate
Brine Salt Mass Fraction		1	Adequate
Brine Viscosity		1	Adequate
Brine Density		1	Adequate
Brine Compressibility		1	Adequate
Castile Brine Reservoir Rock Compressibility	Castile	1	Adequate
Castile Brine Reservoir Porosity		1	Adequate
Castile Brine Reservoir Pressure		1	Adequate
Castile Brine Reservoir Permeability		3	Adequate
Castile Brine Reservoir Volume		1	Adequate
Non-Salado Effective Porosity	Units Above the Salado	6	Adequate
Non-Salado Pressure		4	Adequate
Non-Salado Permeability		6	Adequate
Culebra Permeability		3	Adequate
Climate Index		1	Adequate
Culebra Transmissivity Data		100 Values	Adequate[1]
Culebra Thickness		1	Adequate
Culebra Storativity		1	Adequate
Culebra Fluid Density		32 Values	Adequate
Culebra Steady-State Freshwater Heads		31 Values	Adequate
Culebra Dolomite Grain Density		1	Adequate
Effective Culebra Thickness		1	Adequate
Advective Porosity		1	Adequate
Half Matrix Block Length		1	Adequate
Diffusive (Matrix) Porosity		1	Adequate
Diffusive (Matrix) Tortuosity		1	Adequate

[1] One of the 21 data packages for the Culebra Transmissivity parameter was deemed inadequate.

The NBPR panel's concern (in italics), the DOE's interpretation of the panel's concern (Statement of Issue), and the DOE response (Response to Issue) are provided in CCA Appendix PEER. The panel then reviewed the response to determine whether the DOE understood the issue and provided a reasonable response (Peer Reviewer Consideration of Response). The justification for the DOE's continued use of the Well P-18 transmissivity value is also provided (DOE Technical Position versus Panel Issue) in CCA Appendix PEER and is reproduced below.

Regarding the transmissivity value selected for the well P-18, the DOE's technical position is that the appropriate transmissivity value was selected; however, whichever transmissivity value is used (4.6×10^{-9} m^2 /s or 7.5×10^{-11} m^2 /s) (4.3×10^{-3} ft^2/day or 7×10^{-5} ft^2/day), the well P-18 data point does not substantially influence the critical migration pathways through the Culebra. This interpretation is supported by the panel in Table 1.1 of its report (CCA Appendix PEER), where the Culebra Transmissivity Data was determined to be adequate.

9.3.6 Waste Form and Disposal Room Data Qualification Peer Review

A Waste Form and Disposal Room (WFDR) Peer Review Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of TP 10.5. The plan describes the process used to plan and perform the review. The purpose of the peer review was ensure that the scientific data used in the models describing the waste form and the disposal room closure and chemistry are qualified for use in the WIPP PA.

The DOE used IRTs to carefully review the existing data necessary to support the PA. Many of the existing data were qualified because the QA program in place at the time of its collection was equivalent in effect to ASME NQA requirements. However, some of the data needed to support the waste form and disposal room models were not qualified by the IRTs.

In accordance with 40 CFR § 194.22 (b), a panel consisting of the following two members was selected to review data that had not been qualified by the IRTs:

- Duane C. Hrncir (Chairman), University of Texas at Dallas; and
- Robert D. Knecht, Colorado School of Mines.

Dr. Hrncir is an associate professor of chemistry and former head of the chemistry programs at the University of Texas at Dallas. He has 24 years of experience in research involving the interactions of metals with organic molecules.

Dr. Knecht is a research professor at the Colorado School of Mines and holds a Ph.D. in Chemical-Petroleum Refining Engineering and a Ph.D. in Metallurgical Engineering. He has provided management and technical assistance to a variety of energy, minerals, and waste industries and to government.

The panel members were both highly qualified to conduct this review and were independent of the WIPP PA program. Additional information concerning the qualifications of the panel members is provided in the peer review panel report (see CCA Appendix PEER). Documentation regarding the independence of the panel members is also provided in CCA Appendix PEER.

The panel received administrative orientation and training on the peer review plan, 40 CFR Parts 191 and 194, NUREG-1297, the QAPD, and TP 10.5. During the course of its work, the panel reviewed information packages provided by SNL for each parameter. In addition, technical reports, published literature, and internal documents supplemented information in the parameter packages. Discussions were held with SNL staff to more fully understand the concepts and parameter derivation.

The panel members evaluated existing data and information that form the basis of the parameter values used to mathematically express conceptual models for the waste form and disposal room subsystem. As discussed above, the parameters evaluated had not previously been fully qualified for use in PA. The conceptual models used in the PA of the waste form and disposal room subsystem include components of:

- Gas generation;
- Chemical conditions;
- Dissolved actinide source term; and
- Colloidal actinide source term.

The WFDR peer review panel evaluated 26 parameters against the eight NUREG-1297 review criteria. The parameters were solubilities of the actinides from the repository wastes in brines from the Salado and Castile.

The panel compared each calculated solubility parameter to those published in the peer-reviewed literature, when such data were available. To make this comparison, the panel considered compatibility of solvents, solution pH, and the absence of potentially ligating carbonate. The latter criterion is an imposed condition controlling the disposal room chemistry. When literature values were unavailable, the panel considered experimental data obtained from several different laboratories. In using these data, the panel evaluated the experimental approach to ascertain that the methods used for data acquisition and interpretation were consistent with recognized standards.

When experimental data were not available for particular parameters, the panel examined the method of calculation used to derive the value. The experimental data used as input to the calculation were evaluated and the validity of the calculation result was critiqued relative to similar calculated values where experimental data were available.

The panel members carefully reviewed each of the 26 parameters submitted for peer review. Based on their review, the panel prepared a final report in July 1996. A copy of the final report is provided in CCA Appendix PEER.

Table 9-5 provides a listing and status of the reviewed parameters. As shown in Table 9-5, the panel concluded that all 26 values were qualified for use in the WIPP PA of actinide solubility under repository conditions. Therefore, the data supporting these parameters are qualified per 40 CFR § 194.22(b).

9.3.7 Passive Institutional Controls Peer Review

40 CFR § 194.43 states that

> Any compliance application shall include detailed descriptions of the measure that will be employed to preserve knowledge about the location, design, and contents of the disposal system.

Table 9-5. Listing and Status of Reviewed Parameters

ID number	Species	Brine	Status
A. Inorganic Chemistry Controlled by $Mg(OH)_2/MgCO_3$			
WP037105	Am(III)	Salado	Qualified
WP037106	Am(III)	Castile	Qualified
WP037109	Pu(III)	Salado	Qualified
WP037108	Pu(III)	Castile	Qualified
WP037129	General An(III)	Salado	Qualified
WP037125	General An(III)	Castile	Qualified
WP037110	Pu(IV)	Salado	Qualified
WP037111	Pu(IV)	Castile	Qualified
WP037115	Th(IV)	Salado	Qualified
WP037112	U(IV)	Salado	Qualified
WP037130	General An(IV)	Salado	Qualified
WP037126	General An(IV)	Castile	Qualified
WP037131	General An(V)	Salado	Qualified
WP037127	General An(V)	Castile	Qualified
WP037113	U(VI)	Salado	Qualified
WP037114	U(VI)	Castile	Qualified
WP037132	General An(VI)	Salado	Qualified
WP037128	General An(VI)	Castile	Qualified
B. Organic Chemistry Controlled by $Mg(OH)_2/MgCO_3$			
WP037116	General An(III)	Salado	Qualified
WP037121	General An(III)	Castile	Qualified
WP037117	General An(IV)	Salado	Qualified
WP037122	General An(IV)	Castile	Qualified
WP037118	General An(V)	Salado	Qualified
WP037123	General An(V)	Castile	Qualified
WP037120	General An(VI)	Salado	Qualified
WP037124	General An(VI)	Castile	Qualified

A Passive Institutional Controls Peer Review Plan (see CCA Appendix PEER) was developed and approved in accordance with the requirements of TP 10.5. The plan describes the peer review process used to ensure that the passive institutional controls proposed by the DOE will reasonably preserve knowledge about the location, design, and contents of the WIPP disposal system and reduce the likelihood of inadvertent intrusion.

A three-member panel of experts was convened in May 1996 to conduct an independent peer review of the system of passive institutional controls designed by the DOE. The panel reviewed the findings of the Passive Institutional Controls Task Force (PTF), evaluating detailed descriptions of the measures intended to preserve knowledge about the location, design, and contents of the WIPP disposal system. The evaluation determined whether the passive institutional controls are adequate and have a reasonable expectation of reducing the likelihood of inadvertent intrusion.

The panel members were:

- Jessica Glicken (Chairman), Ecological Planning and Toxicology, Inc.;
- Elizabeth K. Hocking, Argonne National Laboratory; and
- Paul R. La Pointe, Golder Associates.

The panel members were well-qualified for this review and independent of the WIPP PA program. Additional information concerning the qualifications of the panel members is presented in the panel report (see CCA Appendix PEER). Documentation of the panel member's independence from the WIPP project is also provided in CCA Appendix PEER.

After administrative orientation and training, the panel members familiarized themselves with regulations impacting radioactive waste disposal at the WIPP (40 CFR Parts 191 and 194) and requirements for the conduct of peer reviews (NUREG-1297 and TP 10.5). Following briefings by members of the PTF and other WIPP project staff, panel members were provided two documents that formed the basis of their peer review:

> Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the Waste Isolation Pilot Plant for Use in Performance Assessments (referred to as the Passive Institutional Controls Efficacy Report; see DOE (1996a, Appendix EPIC); and,

> Passive Institutional Controls Conceptual Design Report (referred to as the Conceptual Design Report (CDR); see DOE 1996a, Appendix PIC).

Supplemental information requested by the panel was also used in the evaluation.

The peer review panel evaluated the assumptions and results presented in the Passive Institutional Controls Efficacy Report. The panel's findings, as presented in their final report, dated July 1996, are provided below. A complete copy of the panel's report is provided in CCA Appendix PEER.

The panel identified several concerns during their review. The panel's concerns, the DOE's interpretation of the panel's concerns (Statement of Issue), the DOE's response to the panel's concerns ("Response to Issue"), and the panel's reaction to the interpretation and responses ("Peer Reviewer Consideration of Response") are provided in CCA Chapter 9. When the panel determined the response did not reasonably address their concerns, the DOE's justification for its position (DOE Technical Position versus Panel Issue) was provided (see CCA Chapter 9).

9.4 Peer Reviews Conducted in Addition to Those Required by 40 CFR Part 194.27(a)

40 CFR Part 194 states that

> Additionally, this section requires compliance applications to include documentation of any peer review activities that DOE may have conducted apart from those required by this rule, including those activities which are similar to peer review, such as the reviews conducted by the WIPP Panel of the National Academy of Sciences. (61 FR 5228)

and that

> Peer review which has been conducted prior to today's action must be documented in compliance applications.

Over the course of the WIPP endeavor, the project has undergone extensive review. The reviews included in this section of the CCA were conducted prior to implementing 40 CFR Part 194 and are briefly mentioned in this section. Additional reviews not specifically required by 40 CFR Part 194.27(a) and conducted after submitting the CCA are described in more detail in this section. They provide additional information to the peer reviews specifically stated in 40 CFR § 194.27(a). These reviews were evaluated against criteria developed from 40 CFR Parts 191 and 194 and NUREG-1297 to determine which ones were appropriate for incorporation in this application. The following criteria were used to screen the historical reviews:

1. Was the peer review relevant to this application?

   The purpose of this application is to demonstrate the WIPP's continued compliance with the disposal regulations found in 40 CFR Part 191. 40 CFR Part 194 provides significant detail concerning the necessary contents of the application. Reviews that cover subject matter pertinent to those contents are considered relevant to this application.

2. Was there a formal report by the reviewer?

   NUREG-1297 requires a peer review to be documented.

3. Was the review a peer review, rather than a technical review?

   NUREG-1297 states that

   > A peer review is an in-depth critique of the assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed, and of conclusions drawn from the original work. Peer reviews confirm the adequacy of work. In contrast to peer review, the term "technical review," as used in this GTP, refers to a review to verify compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.

4. Was the review a peer review, rather than an expert judgment?

   As discussed above, a peer review confirms the adequacy of the work being reviewed. 40 CFR Part 194 states that

   > Typically, expert judgment is used to elicit two types of information: (1) Numerical values for parameters (variables) which are measurable only by experiments that cannot be conducted due to limitations of time, money and physical situation; and (2) essentially unknowable information, such as which features should be incorporated into passive institutional controls that will deter human intrusion into the repository. (61 FR 5228)

5. Was the technical expertise of the reviewer at least that needed to perform the original work?

   NUREG-1297 states that

   > The technical qualifications of the peer reviewers, in their review area should be at least equivalent to that needed for the original work under review and should be the primary consideration in the selection of peer reviewers. Each peer reviewer should have recognized and verifiable technical credentials in the technical area he or she has been selected to cover. The technical qualifications of each peer, and hence of the peer review group as a whole, should relate to the importance of the subject matter to be reviewed.

6. Were the reviewers independent?

   A. Were they involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed?

   B. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?

   Regarding the reviewers' independence, NUREG-1297 states:

   > Members of the peer review group should be independent of the original work to be reviewed. Independence in this case means that the peer, a) was not involved as a participant, supervisor, technical reviewer or advisor in the work being reviewed, and b) to the extent practical, has sufficient freedom from funding considerations to assure the work is impartially reviewed.
   >
   > Because of DOE's pervasive effort in the waste management area, the lack or unavailability of other technical expertise in certain areas, and the possibility of reducing the technical qualifications of the reviewers in order that total independence is maintained, it may not be possible to exclude all DOE or DOE contractor personnel from participating in a peer review. In those cases where total independence cannot be met, a documented rationale as to why someone of equivalent technical qualifications and greater independence was not selected should be placed in the peer review report.
   >
   > The pervasive nature of DOE's effort in the waste management area also makes it necessary that both the work under review as well as the peer review of this work be allowed to be funded by DOE.
   >
   > The independence criteria is not meant to exclude eminent scientists or engineer upon whose earlier work certain of the work under review is based so long as a general scientific consensus has been reached regarding the validity of their earlier work.

7. If the answer to any of the above questions is no, is there an overriding consideration that would still serve to qualify the review as an appropriate and acceptable peer review for incorporation into the historical review section of this application?

Interviews with former and current WIPP project personnel were conducted to identify past reviews that should be considered for inclusion in this application. Records of the historical reviews were obtained and evaluated against the above screening criteria to select the specific reviews to document in the application. The selected reviews are discussed below. Copies of the reports that were published prior to the submission of the CCA were provided in CCA Appendix PEER; those published after the CCA are provided in Appendix PEER-2004.

A historical review may provide an evaluation of completed work by the WIPP project; for example, the Engineered Alternatives Task Force Report (DOE 1991) review. In most cases, however, the reviews were sought by the project to seek guidance and an outside perspective as to appropriate “next steps.” It should be remembered that most of these reviews were actually evaluating work in progress. They focus on the status of ongoing work at a specific point in time to guide future emphasis and direction of the work and, by their very nature, tend to accentuate aspects of the work that need improvement. They have been very important to the WIPP project because they have consistently provided an understanding of deficiencies and contributed heavily in guiding the project’s future direction and needs. The historical peer reviews provide an overall perspective of the evolution and growth of the project.

9.4.1 NAS WIPP Panel Reviews

The National Research Council was established by the National Academy of Sciences (NAS) in 1916. The Council operates in accordance with Academy general policies under the authority of the NAS congressional charter of 1863. The National Research Council has become a principal NAS operating agency for providing services to the government, the public, and the scientific and engineering communities.

In March 1978, the DOE requested the National Research Council:

> review the scientific and technical criteria and guidelines for designing, constructing and operating a Waste Isolation Pilot Plant for isolating radioactive wastes from the biosphere.

The National Research Council assigned the study to the Committee on Radioactive Waste Management under the Commission on Natural Resources. The Committee organized the panel on the WIPP to:

> …review the scientific and technical adequacy of the site-suitability criteria; the guidelines for the site confirmation studies; the design criteria for the repository, including the waste acceptance criteria, the design philosophy, and the operational philosophy; the criteria for determining the environmental safety of future planned operations, viewed from the perspective of the environmental conditions of the repository site; and the design criteria for the experimental testing program of the behavior of the waste-geologic medium interaction.

Panel members were independent of the WIPP project and were nationally recognized experts in their respective disciplines. The panel was selected to provide an appropriate balance of relevant technical disciplines. The scope of the panel’s expertise was very broad and included environmental engineering, geology, geochemistry, nuclear science and technology, nuclear engineering, materials science, and mining engineering. The panel regularly made use of other members of the National Research Council Board of Radioactive Waste Management and/or consultants, as necessary, to provide additional expertise.

The panel remained active from 1979 to 1996, during which time its membership changed due to retirement of some members and induction of new members to fill vacancies or to provide coverage in newly identified subject specialties. However, a continuity of knowledge about the

WIPP project was maintained because of a significant overlap of members. Names and backgrounds of members who served on the initial NAS WIPP panel were provided in CCA Chapter 9 and CCA Appendix PEER. Two additional panels have been constituted since 1997 to address specific issues requested by DOE. The membership of those panels and their work is described later in this section.

Between 1979 and 1996, the first WIPP panel produced several reports reflecting their review efforts. An evaluation of the NAS reviews against the previously described screening criteria is provided in Table 9-6. Summaries of the review reports are provided in the following sections. This chapter includes only the titles of the old reports discussed at length in CCA Chapter 9. The reports published by the new NAS panels after the submission of the CCA are described in this chapter.

9.4.1.1 Letter Report of May 1, 1979

See CCA Section 9.4.1.1 for details.

9.4.1.2 Letter Report of September 10, 1979

See CCA Section 9.4.1.2 for details.

9.4.1.3 Continuing Evaluation of the Carlsbad Site

This July 28, 1980 report (see CCA Appendix PEER) reviewed the Carlsbad site in light of the President's decision to cancel the WIPP project. See CCA Section 9.4.1.3 for details.

9.4.1.4 Review of the Criteria for the Site Suitability, Design, Construction, and Operation of the Proposed Waste Isolation Pilot Plant (WIPP); Progress Report: July 1, 1978, to December 31, 1979

This September 1981 report (see CCA Appendix PEER) recounts the panel's findings through the end of 1979. See CCA Section 9.4.1.4 for details.

9.4.1.5 Review of the Criteria for the Site Suitability, Design, Construction, and Operation of the Proposed Waste Isolation Pilot Plant (WIPP); Interim Report: July 1, 1978, to July 31, 1982

This 1983 report (see Appendix PEER) updates the panel's review of WIPP and recounts the panel's findings through the end of July 1982. See CCA Section 9.4.1.5 for details.

Table 9-6. NAS WIPP Panel Reviews

1. Is the peer review relevant to the CCA?	Yes – The panel has dealt with many WIPP issues and most are directly relevant to the CCA.
2. Was there a formal report prepared by the reviewer?	Yes – There have been a series of formal reports.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – Most of the reviews have addressed the adequacy of PA, site selection, etc., activities at WIPP.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – The reviews have all evaluated the adequacy of work prepared by the WIPP project or others.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – Panel members are nationally recognized experts in their respective fields.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – The panel was established by the National Research Council in the 1970s.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A – However, 40 CFR 194 (Supplementary Information re: §194.27) specifically indicates the NAS Panel reviews are appropriate for the CCA.

9.4.1.6 Review of the Scientific and Technical Criteria for the Waste Isolation Pilot Plant (WIPP)

This 1984 report (see CCA Appendix PEER, Section PEER 9.6) updates the panel's review of the WIPP and recounts the panel's findings through December 31, 1983. See CCA Section 9.4.1.6 for details.

9.4.1.7 Letter Report of April 1987 on Planned Sorbing-Tracer Field Tests

The WIPP panel considered the sorbing-tracer field test planned at WIPP and provided their comments in April 1987 (see CCA Appendix PEER). See CCA Section 9.4.1.7 for details.

9.4.1.8 Report of March 3, 1988 on Brine Accumulation in the WIPP Facility

See CCA Section 9.4.1.8 for details.

9.4.1.9 Letter Report of December 1988 on Experiments of Room Closure Rates

See CCA Section 9.4.1.9 for details.

9.4.1.10 Review Comments on DOE Document DOE/WIPP 89-011: Draft Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment and Operations Demonstration

This July 19, 1989 report (see Appendix PEER) documents the WIPP panel's review of the subject document. See CCA Section 9.4.1.10 for details.

9.4.1.11 Letter Report of April 1991, Summary of Recommendations

This April 1991 report (see CCA Appendix PEER) summarizes the views of the WIPP panel on the status of the DOE program to assess the WIPP's ability to isolate TRU waste and to demonstrate compliance with relevant regulations. See CCA Section 9.4.1.11 for details.

9.4.1.12 Letter Report of June 1992

This June 1992 report (see CCA Appendix PEER) addressed the experimental plan for the WIPP and was based principally on a review of various documents submitted to the panel and presentations by the DOE and its contractors before the panel over the preceding three years. See CCA Section 9.4.1.12 for details.

9.4.1.13 The Waste Isolation Pilot Plant: A Potential Solution for the Disposal of Transuranic Waste (NAS 1996)

The final report of the NAS Committee set up in 1978 was published in October 1996. Since this report was published after the submission of the CCA, it was not included in the CCA. The full report is reproduced in Appendix PEER-2004.

The members of the committee, who also authored the report, were:

- Charles A. Fairhurst;
- Howard I. Adler;
- John O. Blomeke;
- Sue B. Clark;
- Fred M. Ernsberger;
- Rodney C. Ewing;
- John B. Garrick;
- Leonard F. Konikow;

- Konrad B. Krauskopf;
- Della M. Roy;
- David A. White;
- Chris G. Whipple; and
- Thomas A Zordan.

Biographies of the members are included in Appendix PEER-2004.

The National Research Council Committee on the WIPP was formed in 1978 at the request of DOE to provide scientific and technical evaluations of DOE investigations at WIPP. The committee's statement of task charged it to report on the current state and progress of the scientific and technical issues that form the core of a submission by DOE to EPA for certification of the WIPP facility. The committee reported the following findings, conclusions, and recommendations. The text in the rest of this section represents the views of the NAS committee and not necessarily those of DOE.

9.4.1.13.1 Findings

With regard to the results of committee evaluations and their implications for the overall suitability of WIPP as a repository for TRU waste, this report presented the following findings:

- Although TRU waste contains long-lived radionuclides that require geologic isolation, the overall level of radioactivity is much lower than that of high-level radioactive waste.

- The early recognition of salt as an attractive medium for geological isolation (e.g., National Research Council/National Academy of Sciences 1957) of radioactive waste has been confirmed by subsequent studies.

- Provided it is sealed effectively and remains undisturbed by human activity, the committee finds that the WIPP repository has the ability to isolate TRU waste for more than 10,000 years. The geologic stability and isolation capability of the Salado, which consists of bedded salt, are the primary factors leading to this finding.

- The only known possibilities for serious release of radionuclides appear to be from poor seals or some form of future human activity that results in repository intrusion. The committee anticipates that the consequences of such human intrusion can be reduced based on available engineering design options and on improved understanding obtained from ongoing scientific studies.

- EPA's regulations (i.e., 40 CFR 191, as specified for WIPP in 40 CFR 194) relating to human intrusion do not take into account that if radionuclide releases to the environment via groundwater pathways at WIPP occur, they will be predominantly in non-potable water. This greatly reduces the risk of human exposure compared to a similar release in potable water.

9.4.1.13.2 General Conclusions and Recommendations

The combination of general considerations, such as those outlined above, and detailed studies described later in this report, led the committee to the following conclusions and recommendations.

Based on available scientific evidence, the only probable threat to satisfactory isolation performance of the repository is the possibility of disturbance by human activity, deliberate or unintentional, that could compromise the repository's integrity. Engineering methods are available, if needed, to reduce the consequences of human intrusion to acceptable levels.

Conclusion: Human exposure to radionuclide releases from TRU waste disposed in WIPP is likely to be low compared to U.S. and international standards.

Considering the consequences of future activities that could violate the natural or undisturbed integrity of the repository is valuable for assessing the relative vulnerability of the repository to such activities and in identifying ways to reduce this vulnerability, but assessing human technologies thousands of years hence is highly conjectural and lacks a sound scientific foundation.

Recommendation: Speculative scenarios of human intrusion should not be used as the sole or primary basis to judge the acceptability of WIPP (and, by extension, any geological repository).

9.4.1.13.3 Findings, Conclusions, and Recommendations on Department of Energy Studies

The following comments of the committee related specifically to the DOE compliance (with 40 CFR Parts 191 and 194) activities. According to the committee, most of the issues discussed below are significant only in the event of human intrusion.

9.4.1.13.3.1 *The Role of Performance Assessment*

PA examines the combined effect of each component of the total system to assess the overall ability of the repository to isolate radionuclides from the biosphere. As used by DOE, PA responds to the question, "Is WIPP in compliance with federal regulations?"

Although PA has made important contributions to the WIPP project, in retrospect, it is clear that the potential of PA is greater, and important opportunities to put PA to good use have been missed. PA is valuable at all stages of the repository evaluation process. It can identify the most critical components of the system, assess the significance of engineered supplements to the natural geological barriers, and aid planning and management decisions on the most effective allocation of staff and project resources.

9.4.1.13.3.2 *Conservatism of Performance Assessment Models*

The PA models currently used by DOE are too conservative in some respects. Such conservatism masks the potential for identifying and assessing the benefits of relatively simple engineering design procedures in reducing the consequences of human intrusion.

The assumption that the DRZ bordering the room excavations remains a relatively high-permeability region throughout the first 10,000 years of the repository appears overly conservative. This is in marked contrast to the assumption (see Chapter 4.0) that the DRZ around the shaft will heal, achieving a permeability of between 10^{-16} m^2 (10^{-15} ft^2) and 10^{-18} m^2 (10^{-17} ft^2) within 50 to 100 years and approaching the essentially impermeable condition of intact salt within a small fraction of 10,000 years. Such a conservative assumption with respect to the DRZ in the PA models may prevent a realistic evaluation of the major benefits of waste compartmentation by room and panel seals in reducing the consequences of repository disturbance by intrusion.

9.4.1.13.3.3 *Complexity of Performance Assessment Models*

DOE's PA modeling of radionuclide releases from WIPP involves such complex combinations of many variables that, to the non-specialist, it is not clear how the predicted releases depend on the component FEPs in the geological isolation system.

The committee recommends that DOE develop, in parallel with the complex PA models, simpler versions that provide a more transparent, traceable path from the model inputs to the predicted releases. The insights gained from the simpler model as to which components of the isolation system are most critical to improved repository performance would serve a very useful role in decision-making and in resource allocation for WIPP. It is essential, of course, that the simpler PA models still identify correctly the key FEPs upon which repository performance depends.

To illustrate this recommendation: because plutonium (Pu) is the dominant radioactive element of concern in the WIPP inventory, a simpler model could focus on Pu in the source term to the exclusion of other radioactive elements. However, understanding and predicting the behavior of Pu in the WIPP system is challenging, and experimental work with other actinides is necessary to develop the parameters for Pu required for the PA models, for both the full model and any simpler version. While studies of other actinides are necessary to support the chemical model developed for Pu, a simpler PA of the kind proposed here would consider only Pu isotopes as a source term, and only the dominant pathway(s) for environmental releases, with no more complexity than needed for an adequate representation.

9.4.1.13.3.4 *Waste Characterization*

The waste characterization program considered by DOE does not appear to be based on the needs for information important to an assessment of the long-term facility performance. Ideally, the PA should be used to determine what characterization is required.

9.4.1.13.3.5 *Nonradioactive Constituents of Transuranic Waste*

Nonradioactive hazardous constituents of TRU waste are considered to pose negligible long-term hazards compared to the radioactive constituents of WIPP waste.

9.4.1.13.3.6 *Behavior of Salt at the Waste Isolation Pilot Plant Site*

Time-dependent deformation of the salt and associated stratigraphic layers at WIPP is now understood well enough to allow reliable long-term calculations of salt deformation behavior as it relates to repository performance.

9.4.1.13.3.7 *Salado Brine*

Small quantities of brine seep from the DRZ in the immediate vicinity of any excavation in the Salado. The amount of brine accumulation is not sufficient to be a credible cause for significant escape of radionuclides from the sealed repository.

9.4.1.13.3.8 *Non-Salado Brine*

Apart from possible effects of deep-well fluid injection in adjacent areas, brine flooding is only likely if, after loss of administrative controls, an intrusion borehole connects the repository with a deeper source of pressurized brine, as has been encountered by some deep boreholes in the vicinity of the repository.

9.4.1.13.3.9 *Gas Generation in the Repository*

Gas generation will be minimal in a dry or nearly dry repository like WIPP because both chemical and biological gas-generating processes (e.g., metal corrosion and bacterial action on organic matter) require a liquid phase for mass transport of the reactants and products that are involved in gas formation.

9.4.1.13.3.10 *Treatment of Waste*

Sophisticated treatment (e.g., incineration) of the TRU waste in a well-engineered WIPP repository is unwarranted to further improve repository performance, because gas generation is not a serious concern (see Chapter 3.0).

9.4.1.13.3.11 *Backfilling and Compartmentation*

Simple repository engineering measures, such as backfilling the rooms and tunnels in which the waste is emplaced, can be valuable and cost-effective methods of reducing the consequences of human intrusion and any associated brine flooding. Room and panel seals via backfill are relatively well-defined engineering procedures for improving the isolation process. In this regard, compartmentation is recommended by the committee to provide effective seals that eliminate hydrological communication between the waste-filled rooms.

9.4.1.13.3.12 *Non-Salado Hydrology*

A more comprehensive understanding of the non-Salado hydrology is needed before a reasonable judgment can be made as to the role of the Rustler and adjacent formations in delaying radionuclide releases in the event of human intrusion. To date, studies have been overly focused on a two-dimensional (2-D) analysis of the Culebra Dolomite. They have not sufficiently considered other possible hydrogeologic release pathways for radionuclides or interconnections between the Culebra and other formations. Potential releases to the Dewey Lake Red Beds, which are less conductive than the Culebra, but contain some potable water, are recommended for further study.

9.4.1.13.3.13 *Potash Mining*

The consequences to the non-Salado hydrology of subsidence damage due to possible future mining of potash resources above the repository have not yet been evaluated by DOE. If the potential consequences are found to be seriously adverse, it is technically feasible to extract these resources preemptively, in a way that avoids subsidence and associated effects and that reduces the potential for human intrusion by drilling.

9.4.1.13.3.14 *Deep Well Fluid Injection*

The requirement to consider the effects on the repository of fluid injection activities was a relatively new addition to the final version of EPA criteria for certification (40 CFR part 194.32(c)). Neither the probability nor the effects on the repository from nearby injection of water or brine have been evaluated in detail by the committee, nor has DOE published an analysis of this issue. A comprehensive analysis of the risks and consequences of this scenario should be completed and documented.

9.4.1.13.3.15 *Waste Solubility and Transport*

The PA completed by DOE in 1992, and all subsequent analyses, have consistently identified a set of issues with the greatest impact on the compliance of WIPP in the event of human intrusion and associated brine flooding of the repository. Prominent among these issues are:

- actinide solubilities in brine,
- formation and transport of colloids containing radionuclides, and
- retardation of radionuclides during transport through the Culebra.

The EPA has also identified these issues as critical to its evaluation of the CCA.

At the time of this report, the data and models to represent these three issues in the next version of the PA (to support the CCA) were not available for review.

9.4.1.13.3.16 *Continuation of Experiments and Analyses*

Continuation of analyses and experiments initiated in the WIPP program to address concerns related to Non-Salado Hydrology, Deep Well Fluid Injection, and Waste Solubility and Transport is recommended by the committee, even though the results may not be available in time for the compliance submission. Results of such testing could reduce uncertainties in the long-term performance of WIPP, eliminate concern over other issues, and be useful in judging the cost-effectiveness of various waste isolation procedures at WIPP and other repositories.

In summary, the committee offered the following opinions:

- Provided the WIPP repository is sealed effectively and undisturbed by human activity, the committee knows of no credible or probable scenario for release of radionuclides.

- For the WIPP repository disturbed by future human activity, the committee has noted three ways in which confidence in the performance of the repository could be increased:

1. Re-evaluation of the probability and/or consequences assigned to highly speculative scenarios of future human activities may reduce the estimated risk of radionuclide release.

2. Experimental and field programs in progress or planned may show that key parameters (e.g., actinide transport) are well within the range required to reduce the impacts of human activities on radionuclide releases substantially.

3. The implementation of available engineering options (e.g., compartmentation, treated backfill), which have not been considered in published DOE analyses, could reduce the consequences of human intrusion. The cost effectiveness of these options will depend on the outcome of (1) and (2) above.

The committee believes that some combination of the above three considerations will very probably be sufficient to allow DOE to demonstrate that a WIPP repository will keep radionuclide release within acceptable levels for the disturbed case.

9.4.1.14 Improving Operations and Long-Term Safety of the Waste Isolation Pilot Plant – Final Report (April 2001)

Following the publication of the NAS WIPP committee's 1996 report described in Section 9.4.1.13, a new NAS WIPP committee was created to carry out the tasks described below. The committee produced an interim report in April 2000 that was included as Appendix A1 of this final report (National Research Council/National Academy of Sciences 2001). The full report is included in Appendix PEER-2004. Since the main findings and recommendations from the interim report have been incorporated into the body of this report, the interim report is not discussed separately in this chapter.

The committee's task was twofold: (1) to identify technical issues that could be addressed to enhance confidence in the safe and long-term performance of the repository, and (2) to identify opportunities for improving the National TRU Program for waste management, especially with regard to the safety of workers and the public.

The following members served on this committee:

- B. John Garrick, Chair, Garrick Consulting, Laguna Beach, California;
- Mark D. Abkowitz, Vanderbilt University, Nashville, Tennessee;
- Alfred W. Grella, Grella Consulting, Locust Grove, Virginia;
- Michael P. Hardy, Agapito Associates, Inc., Grand Junction, Colorado;
- Stanley Kaplan, Bayesian Systems Inc., Rockville, Maryland;
- Howard M. Kingston, Duquesne University, Pittsburgh, Pennsylvania;

- W. John Lee, Texas A&M University, College Station;
- Milton Levenson, Bechtel International, Inc. (retired), Menlo Park, California;
- Werner F. Lutze, University of New Mexico, Albuquerque;
- Kimberly Ogden, University of Arizona, Tucson;
- Martha R. Scott, Texas A&M University, College Station;
- John M. Sharp, Jr., The University of Texas, Austin;
- Paul G. Shewmon, Ohio State University (retired), Columbus;
- James E. Watson, Jr., University of North Carolina, Chapel Hill; and
- Ching H. Yew, The University of Texas (retired), Austin.

In addition, Dalene C. Hoffman and James O. Leckie served as liaisons and Lynda L. Brothers and John T. Smith served as consultants. National Research Council/National Academy of Sciences staff members Barbara Pastina and Thomas E. Kiess served as Study Directors and Angela R. Taylor as Senior Project Assistant. Biographies of the committee members are provided in the report (National Research Council/National Academy of Sciences 2001) (see Appendix PEER-2004).

The text in the rest of this section represents the views of the NAS committee and not necessarily those of DOE.

9.4.1.14.1 Findings and Recommendations

The overarching finding and recommendation of this report is that the activity that would best enhance confidence in the safe and long-term performance of the repository is to monitor critical performance parameters during the long preclosure phase of repository operations (35 to possibly 100 years). Indeed, in the first 50 to 100 years, the rates of important processes such as salt creep, brine inflow (if any), and microbial activity are predicted to be the highest and will be less significant later. The committee recommends that the results of the on-site monitoring program be used to improve the PA for recertification purposes. These results will determine whether the need for a new PA is warranted. For the National TRU Program, the committee finds that the DOE is implementing many of the recommendations of its interim report. It is important that the DOE continue its efforts to improve the packaging, characterization, and transportation of the TRU waste.

The committee's specific findings and recommendations have been grouped into three categories: (1) site performance, (2) site characterization, and (3) the National TRU Program, as described below.

9.4.1.14.1.1 *Site Performance*

- The committee recommends preclosure monitoring to gain information on brine migration and moisture access to the repository. Observation should continue at least until the repository shafts are sealed and longer, if possible. The committee recommends that the results of the on-site monitoring program be used to improve the PA for recertification purposes.

- The committee recommends preclosure monitoring of gas generation rates, as well as of the volume of H, carbon dioxide (CO_2), and CH_4 produced. Such monitoring could enhance confidence in the performance of the repository, especially if no gas generation is observed. Observation should continue at least until the repository shafts are sealed and longer, if possible. The results of the gas generation monitoring program should be used to improve the PA for recertification purposes.

- MgO is used as backfill in WIPP to provide some control of the chemical environment of the waste and, to a lesser extent, to fill voids in the disposal locations, thus enhancing the healing process. The chemical performance of MgO depends on gas generation and brine inflow, as well as other chemical processes taking place in the repository. The committee finds that there is uncertainty about the effectiveness of MgO in controlling the chemical environment of the waste. Therefore, the committee recommends that the net benefit of MgO used as backfill be reevaluated. The option to discontinue emplacement of MgO should be considered.

- The committee recommends preclosure monitoring of the status of room deformation and of the DRZ healing. Seal performance should also be assessed. Observation should continue at least until the repository shafts are sealed and longer, if possible. The results of the monitoring of room deformation and DRZ healing should be included in the PA and used for recertification purposes.

9.4.1.14.1.2 *Site Characterization*

- The committee recommends a monitoring program to characterize the geohydrology of the Culebra Dolomite. Tests and measurements that should be considered include angled boreholes, natural gradient tracer tests, and additional pump or injection tests. These new data should be used to confirm or modify the conceptual and numerical models now proposed as a reasonable simulation of the actual system.

- The committee recommends the use of seismic survey techniques for detecting large brine reservoirs below the repository. In case a brine reservoir was found beneath the WIPP and its size was larger than what is already taken into account in the PA, the DOE should conduct an extensive review of the impact of such a reservoir on the repository performance. A basis would then exist to take appropriate action to ensure repository safety.

- The committee recommends developing a database to collect information on drilling, production enhancement, mining operations, well abandonments, and unusual events (accidents and natural events) in the vicinity of the WIPP site.

- The committee recommends that the DOE continue implementing its plan to sample oil-field brines, petroleum, and solids associated with current and future hydrocarbon production, as necessary, to assess the magnitude and variability of naturally occurring radioactive material (NORM) in the vicinity of the WIPP site for baselining purposes.

9.4.1.14.1.3 *The National Transuranic Program*

9.4.1.14.1.3.1 Waste Characterization and Packaging

The committee recommends that the DOE's efforts to review waste characterization and packaging requirements continue and those changes be implemented over the entire National TRU Program. The committee recommends that the resources required to complete these improvements be made available by the DOE.

9.4.1.14.1.3.2 Total Inventory of Organic Materials Allowed in the Repository

The committee recommends a risk-based analysis of the total organic material regulatory limits in WIPP. If accounting for the organic material is important to the safety of the repository, an inventory record system should be implemented as soon as possible to provide a basis for meaningful safety analysis.

9.4.1.14.1.4 *Waste Transportation*

9.4.1.14.1.4.1 Department of Energy's Communication and Notification Program

The DOE appears to be moving systematically toward the implementation of an efficient, comprehensive, and state-of-the-art communication and notification system called TRANSCOM 2000. The committee recommends that the DOE implement as soon as possible the new TRANSCOM 2000 communication and notification system. Moreover, because the human factor is an important element of transportation system quality, TRANSCOM 2000 should include methods to minimize the occurrence and impact of human errors.

9.4.1.14.1.4.2 Department of Energy's Emergency Response Training

The committee recommends that the DOE facilitate the involvement of states in developing and maintaining an up-to-date, practical, and cost-effective spatial information database system to coordinate emergency responses. The DOE should also develop an ongoing assessment program for states' emergency response capabilities and allocate training resources to address deficiencies in coverage along WIPP routes.

9.4.1.14.1.4.3 Rail as a Transportation Option for Certain Transuranic Waste

The committee recommends that all reasonable transportation options, including reduction in the number of shipments, such as rail and road transportation with better-adapted containers, should be part of the decision-making process of transporting TRU waste from generator and storage sites to the WIPP. Future transportation studies should consider railway shipments and their impact on both the safety and the cost of the program. The DOE should also continue to pursue the development of packaging alternatives for materials not suitable for TRUPACT-ll containers.

9.4.1.14.1.4.4 Gas Generation Safety Analysis for TRUPACT-II Containers

The committee recommends a risk-informed analysis of WIPP specific shipment issues to identify core problems related to hydrogen generation and, perhaps, provide a basis for alternative cost-effective criteria while reducing risk. The committee recommends the use of such risk-informed analysis in the application for revision of the NRC certificate of compliance concerning hydrogen generation limits for transportation purposes.

9.4.14.1.4.5 *The Department of Energy's Response*

The DOE provided detailed responses to most of these recommendations, which are included in Appendix A2 of National Research Council/National Academy of Sciences (2001) (Appendix PEER-2004). In brief, the DOE agreed with the committee's findings and observations and has implemented most of the recommendations.

9.4.1.15 Characterization of Remote-Handled Transuranic Waste for the Waste Isolation Pilot Plant – Final Report (2002)

In 2001, a new NAS WIPP committee (Committee on the Characterization of Remote-Handled Transuranic Waste for the Waste Isolation Pilot Plant) was established to review a proposed characterization plan for RH-TRU waste and to provide recommendations for improving the plan's technical soundness, protection of worker safety and health, and compliance with regulatory requirements. The committee published its final report in 2002 (National Research Council/National Academy of Sciences 2002).

The following members served on the committee and authored the report:

- Eula Bingham, Chair, University of Cincinnati, Ohio;
- Sanford Cohen, SC&A, Inc., McLean, Virginia;
- Milton Levenson, Independent Consultant, Menlo Park, California;
- Kenneth Mossman, Arizona State University, Tempe;
- Ernest Nieschmidt, Idaho State University, Idaho Falls;
- John Plodinec, Mississippi State University, Starkville; and
- Anne E. Smith, Charles River Associates, Washington, D.C.

Heino Nitsche served as a consultant and Alexander Maclachlan served as liaison to the National Research Council/NAS Board on Radioactive Waste Management. The National Research

Council/NAS staff members were Study Director Barbara Pastina, Senior Project Assistant Angela Taylor, and Research Assistant Darla Thompson.

The text in the rest of this section represents the views of the NAS committee and not necessarily those of DOE.

9.4.1.15.1 Committee's Assessment of Department of Energy's Proposed Characterization Plan

The committee used the criteria listed in the statement of task to assess DOE's proposed characterization plan to address: (1) the context of RH-TRU waste characterization, (2) the characterization plan's technical soundness, (3) protection of worker safety and health, and (4) compliance with regulatory requirements.

9.4.1.15.1.1 *Context of Remote-Handled Transuranic Waste Characterization*

DOE should emphasize the argument that the characterization information collected for most of RH-TRU waste does not need confirmatory measurements because the repackaging or generation of waste will be carried out under a certified QA program. If the volume of RH-TRU waste represents between 2 and 4 percent of the volume of TRU waste, and the information collected for over 95 percent of RH-TRU waste does not need confirmation, then only the remaining 5 percent of the RH-TRU waste inventory (between 0.1 and 0.2 percent of the total inventory) needs confirmation activities.

DOE uses the term Acceptable Knowledge (AK) to indicate both the historical information and the newly generated characterization information collected at the time of waste generation, packaging, or repackaging. However, for 95 percent of the RH-TRU waste inventory, AK refers mostly to the latter. The committee recommended that DOE use a different term than AK for this newly generated information. Using AK for both historical and newly generated information is potentially confusing because AK is generally associated with historical information, which requires some type of confirmation.

9.4.1.15.1.2 *Characterization Plan's Technical Soundness*

The committee found that DOE's proposed characterization plan is not completely performance-based, and that several characterization activities are based on nontechnical considerations. The committee questioned the technical bases of some of these characterization activities. The committee acknowledged that nontechnical considerations may be important for maintaining effective working relationships among DOE, EPA, and NMED; however, DOE should propose only characterization activities that have a technical, health and safety, or regulatory basis.

DOE's proposed characterization plan should address tolerable decision error rates associated with characterization information. These errors should not be overly stringent so as to negatively impact the sites' ability to implement ALARA.

The characterization plan should clarify under which conditions confirmation of historical AK is warranted and the most effective methods proposed. DOE should provide justification for the technologies proposed to obtain confirmatory data and provide evidence of their effectiveness across the entire spectrum of dose rates for RH-TRU waste.

9.4.1.15.1.3 *Protection of Worker Safety and Health*

DOE could strengthen the rationale of its characterization plan for RH-TRU waste by discussing estimates of worker doses and characterization costs in the three site-specific plans accompanying the submittal documents. DOE should continue its effort to ensure sufficient flexibility for generator sites in the implementation of the characterization plan. However, characterization activities that share common elements across sites should be standardized.

9.4.1.15.1.4 *Compliance with Regulatory Requirements*

The committee recommends that DOE evaluate whether existing characterization practices for CH-TRU waste, when applied to the characterization of RH-TRU waste, have an impact on the protection of the environment, health and safety of public and workers, and cost-effectiveness of the characterization program.

The committee recommends that submittal documents focus on regulatory requirements under the relevant agency's purview and distinguish between these requirements and ancillary information describing the context of RH-TRU waste characterization.

9.4.1.15.2 Department of Energy's Response

The DOE has taken into account the committee's recommendations in developing the RH-TRU waste characterization plan.

9.4.2 Performance Assessment Peer Review Panel

The Performance Assessment Peer Review Panel (PAPRP) was established in 1987 as a standing group under contract to the WIPP PA Department at SNL. The PAPRP charter states that the purpose for establishment of the panel was as follows:

> An external Peer Review Panel has been established for significant PA documentation so that the DOE can be assured that the performance evaluation is well-conceived and being carried out with professional competence, and so that scientists and state officials can be assured that the DOE's conclusions as to the suitability of the WIPP as a repository are credible.

An evaluation of the PAPRP reviews against the screening criteria is provided in Table 9-7. Panel members were selected on the basis of their professional stature within the university, scientific and/or engineering communities. The PAPRP membership provides expertise in environmental research, geology, nuclear engineering, hydrogeology, and public policy development. Members were chosen explicitly for their independence from PA work undertaken by SNL. Panel members were:

- G. Ross Heath (Chairman), University of Washington;

Table 9-7. Performance Assessment Peer Review Panel

1. Is the peer review relevant to the CCA?	Yes – the PAPRP evaluates SNL PA efforts.
2. Was there a formal report prepared by the reviewer?	Yes – formal reports are developed.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the PAPRP reviews the adequacy of the SNL PA activities.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the PAPRP performs documented, in-depth, critical evaluations of PA reports and other documentation, addressing validity of basic assumptions, alternative approaches, methodology, uncertainty, supportability of conclusions, and consequences of incorrect assumptions or conclusions.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – all members of the PAPRP are recognized experts in their fields.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the PAPRP operates as a independent group under contract to the SNL PA Department. Uncensored comments by the panel are maintained in the SWCF.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

- Robert J. Budnitz, Future Resources Associates, Inc., Berkeley, California;
- Thomas A. Cotton, JK Research Associates, Inc., Washington, D.C.;
- Peter A. Domenico, Texas A&M University (Until 1990);
- C. John Mann, University of Illinois, Urbana;
- Thomas H. Pigford, University of California, Berkeley; and
- Frank W. Schwartz, Ohio State University (since 1990).

The panel finished its work with the preparation of the CCA. The PAPRP chairman was responsible for ensuring that members did not have a conflict of interest.

Panel members were requested to address the following areas, as applicable, for each review:

1. Validity of basic assumptions and extrapolations;
2. Alternative interpretations or approaches;
3. Appropriateness, logic, and limitations of methodology;
4. Uncertainty of results;
5. Supportability of the conclusions drawn;
6. Consequences of incorrect assumptions or conclusions; and
7. Other issues appropriate to the review subject.

The major issues (and their resolutions) raised by the PAPRP during its review of PA documentation from 1987 to 1995 are provided in CCA Chapter 9 and CCA Appendix PEER, Section PEER.11.

9.4.3 Shaft Seal Design Independent Review

A review plan, titled Shaft Seal System Design for the Waste Isolation Pilot Plant (WIPP), was developed and approved on January 12, 1996 (Hansen 1996). The review plan governed the preliminary and final reviews of the WIPP shaft seal system.

Members of the review panel were selected based on their respective knowledge, experience, and independence from the WIPP shaft seal design effort. The group had expertise in computational geomechanics, rock mechanics, mining engineering, civil engineering, and the design and construction of underground seals and bulkheads. The panel for both the preliminary and final reviews consisted of a review team chairman and three reviewers:

- R.E. Stinebaugh (Chairman), SNL;
- Dr. Malcolm Gray, Atomic Energy of Canada Limited Whiteshell Laboratories;
- Stephen Phillips, Phillips Mining; and
- Dr. John Tinucci, Itasca Consulting Group.

A evaluation of the shaft seal design reviews against the screening criteria used to determine whether this review should be addressed in this application is presented in Table 9-8.

Shaft seal design activities were conducted under an approved QA program. The review was conducted in accordance with the requirements of SNL QAP 3-2, entitled Verification of Design Adequacy, approved 7/31/95 (QA Department 1995), and the provisions of the review

Table 9-8. Shaft Seal System Design Review

1. Is the peer review relevant to the CCA?	Yes – the seal system is directly relevant to PA.
2. Was there a formal report prepared by the reviewer?	Yes – the title of the report is "Final WIPP Shaft Seal System Design Review."
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the review focused on the adequacy of the shaft seal system that was developed by SNL
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the review evaluated the adequacy of the work of others (the design of the shaft seal system).
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the reviewers were specifically chosen because of their expertise in seal design and related disciplines.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – it may appear that the independence could be questioned because of the chairman's affiliation with SNL. However, his organizational independence from the WIPP project and his actual role in the review process (see Section 9.4.3 for additional discussion) preserved the independence of the review.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

plan. Panel members were trained in accordance with the provisions of QAP 3-2 prior to beginning the design review. A member of the SNL QA staff (Organization 6860) briefed the panel at the onset of the review, monitored the review as it progressed, and inspected record-keeping activities. Records of panel training and other QA records concerning this review were maintained in accordance with SNL QA program requirements.

In both reviews, the panel was asked to address the following questions:

1. Will the shaft seal system satisfy design guidance?
2. Are there elements of the design that will prevent the sealing system from meeting design requirements?
3. Can the design be successfully implemented?

A short summary of each review is provided below.

Review of the Preliminary Shaft Seal Design

The preliminary design review considered the adequacy of design concepts summarized in DOE (1995c). The report includes descriptions of the WIPP setting, design guidance derived from the regulations, a description of the design, materials comprising the seal components, and preliminary evaluations of the shaft seal system.

The review of the Sealing System Design Report was initiated in January 1996 and completed in March 1996. Following their review of the Sealing System Design Report, Dr. Gray, Dr. Tinucci, and Mr. Phillips prepared detailed comments. These comments were forwarded to the appropriate design staff and formal responses were prepared. The reviewers evaluated the responses and determined their responsiveness to the concern.

Subsequent to resolution of outstanding issues, the updated information was used to amend the documentation provided to the review panel for its final review (discussed below). At the conclusion of the final review, all of the reviewers, without exception, stated that the actions promised in the responses to the preliminary review comments had been completed.

Review of the Final Shaft Seal System Design

During April 1996, the panel was convened to review the Compliance Submittal Design package for the WIPP shaft sealing system (Hansen 1996). Panel input was subsequently incorporated into the final Compliance Submittal Design report (Repository Isolation Systems Department 1996). The review was based on documentation provided by SNL and briefings by the WIPP technical staff. The documentation included an enhanced, annotated outline for the compliance shaft seal design report, detailed drawings, a material specifications framework, and topical summaries of structural and fluid flow calculations. Briefings provided the panel with additional information covering the design, laboratory and in-situ experimentation results, and analyses that were completed.

Following completion of the review, each panel member prepared specific comments regarding the design (see CCA Appendix PEER). The WIPP staff prepared specific responses to the comments and met with the reviewers to resolve them. In some instances, the WIPP staff, in response to the reviewer comments, promised to make certain changes or additions to the design drawings, the documentation of the analyses, or the report test. In some of these cases, a reviewer conditionally accepted those responses but required a copy of the marked up document to remove the condition for full acceptance. The comments were formally tracked with comment resolution forms. In addition, conditionally accepted comments were formally closed by sending the text changes to the reviewer as evidence of the direct incorporation of his or her comments. Final comment closure was documented in the form of a letter from the reviewer stating full acceptance of the changes.

Each reviewer also prepared a summary statement (see CCA Appendix PEER). The summary statements provided recognition or explanation of specific technical concerns in the final documentation, identified the need for future work prior to emplacement of the seals, provided suggestions for design and analysis enhancements or simplifications, and encouraged more detailed quantification of design guidance. Each of the reviewers provided "bottom-line" assessments. Excerpts from the summary statements are provided below:

> In summary and conclusion, I consider that when completed as stated immediately above, it is likely that the documents being developed will present a design that will meet the general requirement of shaft sealing systems that will mitigate against water and gas flows from the repository to the biosphere and that can be built using existing technologies or reasonable extrapolation therefrom. (Dr. Malcom Gray)

> It is considered improbable that the seal design, as presented including the revisions recently discussed, can be significantly and practically improved within the limits of existing construction materials and technologies, except in some areas where optimization of materials and methods of emplacement can be achieved. (Mr. Stephen Phillips)

> The design that has been put forth presents one way of efficiently sealing shafts. Recognizing that other ways could also be made to work, the design presented here is similar to others suggested by the scientific community for sealing deep geologic nuclear waste repositories. The concepts presented have been developed from sound engineering judgment and sound analyses techniques. The anticipated performance of individual sealing components are within reasonable expectations based on currently available field and laboratory data, albeit limited. To address the wide scale of uncertainties, the design has been conservatively laid-out with redundant multiple-barrier components so that the overall seal system performance is not dependent on the functionality of an individual component. The design as it exists today is a conceptual design since it describes basic concepts and provides sufficient backup analyses to demonstrate that those concepts will reasonably satisfy the qualitative design guidelines. (Dr. John Tinucci)

9.4.4 Engineered Alternatives Task Force Report Peer Review

The EATF was established by the DOE in 1989. The EATF was tasked to evaluate the effectiveness, feasibility, and risk of implementing alternative facility designs, backfills, and/or waste forms in improving the long-term performance of the WIPP disposal system. The purpose, methodology, assumptions, and conclusions of the EATF are documented in DOE 1991. The author of the report, IT Corporation, convened a peer review panel to review a final draft version of the report during 1991. An evaluation of the EATF review against the screening criteria is provided in Table 9-9. The panel consisted of experts in chemical and nuclear engineering and geology. The members of the panel and their affiliations were as follows:

- Dr. H. Eric Nutall, University of New Mexico and Nutall & Associates, Inc.;
- Dr. Douglas Brookings, University of New Mexico;
- Dr. Robert J. Budnitz, Future Resources Associates, Inc.; and
- Donald E. Shaw, P.E., Engineering and Management Consultant.

A formal comment resolution process was employed to ensure that the reviewers' comments were incorporated into the final version of the report. The comments of the panel can be grouped into three general topics: (1) quality of technical work, (2) utility of a single figure-of-merit, and (3) use of relative versus absolute risk.

Table 9-9. Engineered Alternatives Task Force Report Review

1. Is the peer review relevant to the CCA?	Yes – the review was conducted on the 1991 EATF report which formed the basis for the subsequent EACBS.
2. Was there a formal report prepared by the reviewer?	Yes – the report consists of review comment record forms that were used to formally document the comments, responses, and their dispositions.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the purpose of the review was to determine the adequacy of the EATF report.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the review evaluated the adequacy of the EATF report.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the reviewers were nationally recognized experts in their respective fields.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the reviewers were not involved in the preparation of the work and were free from funding considerations.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

The comments made by the peer review panel (see CCA Appendix PEER) and the WIPP project responses are discussed below.

9.4.4.1 Quality of Technical Work

One reviewer commented that:

> "The complex technical risk analysis work aimed at determining risk-reduction factors of the many different risk endpoints and for 16 different alternative scenarios, is of high quality and deserves commendation. The technical information buried in the back of the Attachments to this report can provide an excellent basis for decision-makers to understand the various risk issues, and make decisions about them. The choice of alternative scenarios, the assumptions made to limit the scope of the analysis, the risk endpoints identified, and the analysis methods used are all fully

> acceptable to me. I am particularly pleased with how the analysis of specific risk endpoints was accomplished in a way that focused on the key issues relevant to the alternative scenarios. This part of the report can be a gold mine for further study by experts, as well as of use to decision-makers if presented properly."

The future value of the work predicted by the reviewers was an accurate prediction because the methodology and models developed for the EATF formed the basis for the subsequent EACBS (DOE 1995b) performed in 1995. The EACBS was recently the subject for another peer review panel (see Section 9.3.3).

9.4.4.2 Utility of a Single Figure-of-Merit

The reviewers questioned the utility of a single figure-of-merit to express the aggregated risk elements. The EATF used a Multi-Attribute Utility Theory approach to combine the risk components for each alternative into a single value for alternative ranking purposes. These risk components included the routine and accidental risks from waste transportation and handling, exposure to radiation and hazardous constituents in the waste during treatment, and cost, schedule, and benefits to future generations from a safer disposal system. One reviewer commented that:

> Although I admire the attempt to come up with a single figure-of-merit useful to decision-makers by which to judge the overall benefit/disbenefit of each of the various scenarios being studied, in my view the effort has not succeeded. The methodology did use established decision-theory methods to identify and calculate such a single figure-of-merit, and seems to break some new ground, but in my opinion, the single figure-of-merit identified is not sufficiently useful to decision-makers to justify the continuation of work along those lines. In fact, I believe that the use of a single figure-of-merit obscures rather than illuminates the situation. Decision-makers are in my opinion fully capable of dealing with multiple attributes presented separately and of weighing them in their own ways for decision-making purposes--this goes on every day in the upper-management board rooms of large enterprises and agencies. But to make these judgements, decision-makers need the best available disaggregated information about the issues at hand, in this case, the best absolute numbers and uncertainties about the specific risk endpoints. I don't believe that high-level decision-makers generally use aggregated information very much or very well, and I don't believe that the aggregated information based on the single figure-of-merit developed in this report will be of much use.

The WIPP project believed that, although dissaggregated information may be used by many decisionmakers in finance and industry, it was not sufficient for the EATF. A compromise was reached in final version of the EATF report. That compromise consisted of providing both the aggregate and individual risk components. This allows a decisionmaker the option to develop an independent figure-of-merit based on personal weighting factors and preferences.

9.4.4.3 Use of Relative versus Absolute Risk

The EATF methodology involved the calculation of relative risk reduction factors rather than absolute risks for each alternative. These relative risk reduction factors were based on a risk of unity for the baseline case (defined as: no waste treatment; a crushed salt backfill; and the current repository design). Risks for each EA were ratioed against the risk for the baseline case, yielding the risk reduction factor. The main advantage of this relative risk approach is that many parameters that affect absolute risk will cancel when calculating relative risk. Uncertainties in those parameter values do not translate into uncertainties in the relative factors. Some reviewers felt that the calculation of absolute rather than relative risks would have been more useful to decisionmakers. For instance, one reviewer commented that:

> In my view, the approach of identifying and working with risk-reduction factors (RRFs) is a very useful intermediate step toward what is actually needed. Indeed, calculating RRFs is often simpler than calculating absolute magnitudes of risks for reasons cited well in the report. However, I believe that for decision-makers these RRFs cannot adequately substitute for knowing the actual magnitudes of the risks involved, except in special cases, such as when almost no changes occur (RRF near unity) or when absolute risk magnitudes and minuscule small for both the base-case scenario and the alternative scenarios.

The WIPP project concluded that although absolute risks convey a greater amount of information for decisionmakers than relative risks, the calculation of absolute risks were outside the scope of the EATF study and would have entailed a considerably greater effort than was warranted. For instance, calculating absolute long-term risks to future generations for each alternative would require performing a complete PA for each alternative.

9.4.5 Blue Ribbon Panel Peer Review

The Secretary of Energy established the WIPP Blue Ribbon Panel (BRP) in August 1989. The panel was composed of the following five members:

- Dr. Thomas Bahr;
- Robert W. Bishop, esq.;
- Dr. Arthur S. Kubo;
- Leonard C. Slosky; and
- Newal Squyres.

Dr. Bahr, a water quality management expert and the Director of the New Mexico Water Resource Research Institute, was nominated to the BRP by the Governor of New Mexico. Mr. Bishop, General Counsel and Corporate Secretary for the Nuclear Management Resources Council, and Dr. Kubo, a nuclear and civil engineer and a vice president of the BDM Corporation, were appointed to the BRP by the Secretary of Energy. Mr. Slosky, an environmental consultant, and Mr. Squyres, an attorney, were nominated by the Governors of Colorado and Idaho, respectively.

The panel members were each requested to provide an independent technical review of WIPP issues and individually report on the following:

- The concept and timing of DOE’s proposed WIPP Operations Demonstration,
- Whether or not the operations demonstrations should be conducted in parallel with the PA, and

- An evaluation of DOE's validation plan for certification of TRU waste to meet the WIPP WAC.

The panel conducted site visits at the WIPP facility and portions of INEL and the Rocky Flats Plant. The panel met with and/or was briefed by staff from the DOE and its contractors, the NAS Board of Radioactive Waste Management WIPP Panel, the EEG, and the EPA. The panel members were provided an extensive amount of documentation and were encouraged to address questions to the above groups. An evaluation of the BRP review against the screening criteria is provided in Table 9-10.

Table 9-10. Blue Ribbon Panel Review

1. Is the peer review relevant to the CCA?	Yes – the reviews addressed waste certification and PA aspects.
2. Was there a formal report prepared by the reviewer?	Yes – each panel member prepared an individual report.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the panel reviewed the adequacy of work being done primarily at WIPP, Rocky Flats Plant, and INEL.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the panel reviewed DOE plans and processes.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – panel members were specifically chosen by the governors and the Secretary of Energy because of their qualifications.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the panel members were not otherwise associated with the WIPP project.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

Following submission of its reports, the BRP was asked to continue its service by providing their observations and recommendations to the DOE in three areas: (1) continued review of DOE plans to characterize Rocky Flats Plant TRU and mixed waste; (2) assist DOE in developing a strategy for achieving compliance with Resource Conservation and Recovery Act (RCRA) and other environmental regulations at WIPP; and (3) evaluate the Final Test Plan and ancillary documents. Subsequently, DOE expanded the BRP charge to include a management review of the WIPP project, review of the rationale and plans to characterize waste for the test phase, and a review of plans for EAs relating to the waste form.

The BRP was also asked in late November 1989 to comment on questions submitted by members of the New Mexico Congressional Delegation. The questions were: (1) what is the rationale for conducting in-situ experiments at the WIPP rather than at existing waste generation and storage sites; (2) how much waste would need to be emplaced at the WIPP for the experiments; and (3) what are the BRP's recommendations regarding DOE's proposed Operational Demonstration experiments?

The BRP provided individual responses to the congressional delegation and provided testimony to the Senate Committee on Energy and Natural Resources on April 26, 1990. The general observations of the panel were provided to the Senate by Dr. Bahr who stated the following:

> At this point Mr. Chairman, rather than going into my specific observations and recommendations and then having each of the panel members do the same, we decided in order to save time that I would very briefly summarize the general observations of the panel to date. The first and most significant observation in my opinion is that each member of the Blue Ribbon Panel has independently arrived at similar conclusions on each of the issues we were asked to evaluate. Also noteworthy is the high level of congruence of our findings with those of the Advisory Committee on Nuclear Facility Safety (Ahearne Committee). We have also participated in meeting with the WIPP Panel of the National Academy of Sciences and I can report that we also generally share the same views on those issues we have both looked into. Let me now highlight those items upon which members of the Blue Ribbon Panel seem to agree.
>
> 1. The deep bedded salt repository at the WIPP appears to be a safe site for long term isolation of transuranic waste; certainly safer than where this waste is presently stored. Radioactive releases over the long term for an undisturbed WIPP site will probably meet EPA standards (40 CFR 191 Subpart B). Meeting this standard having to consider human intrusion scenarios will be more difficult. Treating the waste so as to change the waste form and thereby force the repository environment to known conditions will significantly reduce present uncertainties. The most controllable variable in the design of the repository environment is the waste form.
>
> 2. In situ testing is important and necessary and should begin as soon as possible. Results of bin and alcove testing should significantly increase the confidence of long range predictions undertaken in the performance assessment. Individual members of the Blue Ribbon Panel agree that the quantity of waste emplaced for experimental purposes should not be limited such as to preclude justifiable experiments. A limit of approximately 1% of the WIPP waste capacity is reasonable. A limit of 0.5% may be too restrictive by precluding the opportunity to undertake important Phase III bin testing of different waste forms resulting from different engineered modifications.
>
> 3. Members of the Blue Ribbon Panel agree conceptually that the EPA suggestion of adding two filled rooms for monitoring purposes is worthy of further consideration by DOE. This approach, however, should be evaluated in the context of verifying facility performance and not considered as part of the test phase itself. We have not, however, been asked to evaluate EPA's suggestion.

> 4. On the subject of Operations Demonstration, our panel agrees that such an undertaking will provide valuable information because of the practical experience gained in system-wide operations. We are in general agreement, however, that a full "ramping up" of an Operations Demonstration should be postponed until such time as the final waste form and repository configuration are determined and that there is a high level of certainty that the Subpart B standard can be met.
>
> 5. We also have general agreement that DOE had underestimated the complexity and level of effort required to comply with RCRA in managing its transuranic-mixed wastes.
>
> Mr. Chairman, I have touched the high points and obviously skipped over many details. Other panel members may wish to elaborate on these and other items. In closing, there is one last item of strong agreement expressed by all panel members. We are very impressed by the responsiveness of DOE to our suggestions. Some examples include 1) The significant improvements that have been made in the DOE organization toward overall systems integration, both vertically and horizontally among the varied elements of transuranic and mixed-transuranic waste management; 2) The significant increase in effort being placed on evaluation of engineered alternatives and waste treatment; 3) The accelerated activity and seriousness with which DOE is now placing on dealing with RCRA and in particular on waste characterization issues; and finally 4) The decision by the Secretary to postpone the start up of the Operations Demonstration program.

The full text of the panel's testimony to the Senate and of the independent reports prepared by the individual panel members are provided in Appendix PEER-2004. There have been significant changes as a result of the recommendations of the BRP and other reviews of the project. These changes are especially dramatic with regard to the PA activities and review. All of the findings and recommendations from the BRP were resolved by the WIPP project to the extent that they were formally closed by the individual BRP members.

9.4.6 Advisory Committee on Nuclear Facility Safety Review

The Advisory Committee on Nuclear Facility Safety (ACNFS) was established by DOE on November 13, 1987, on the recommendation of the NAS. The ACNFS was appointed by the Secretary of Energy to provide advice and recommendations on the safety of DOE's nuclear production and utilization facilities. The facilities reviewed by the ACNFS included the WIPP site and the waste generator sites. An evaluation of the ACNFS review with the screening criteria is provided in Table 9-11.

The ACNFS was composed largely of recognized experts (from outside the DOE) in the field of nuclear energy. Specific expertise of the committee members included environmental chemistry, risk assessment, radioactive waste management, medicine, geology, geochemistry, biophysics, health physics, and environmental regulatory compliance. The ACNFS panel was composed of the following members:

- John Ahearne (Chairman), Sigma Xi;
- Jess Cleveland, U.S. Geological Survey;
- Floyd Culler, EPRI;
- Jacob Fabrikant, University of California, Berkeley;

Table 9-11. Advisory Committee on Nuclear Facility Safety

1. Is the peer review relevant to the CCA?	Yes – The review addressed long term performance, gas generation, and EA issues.
2. Was there a formal report prepared by the reviewer?	Yes – There was a formal report.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes –Although much of the ACNFS's scope could be characterized as technical review, there were other issues, such as the adequacy of the WIPP programs to address gas generation, long term performance, and waste characterization that would be better characterized as peer review.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes –ACNFS reviewed DOE operations, processes and documentation.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes –ACNFS members were recognized experts in the field of nuclear energy.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes –ACNFS members were from outside the DOE and were appointed by the Secretary of Energy under the Federal Advisory Committee Act.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

- William Kastenberg, University of California, Los Angeles;
- Terry Lash, Consultant;
- Harold Lewis, University of California, Santa Barbara;
- James Martin, University of Michigan;
- Dana Powers, SNL;
- William Schull, University of Texas;
- Robert Seale, University of Arizona;

- C. Frederick Sears, Northeast Utilities;
- Gerald Tape, Associated Universities; and
- Victoria Tschinkel, Landers and Parsons.

The ACNFS visited WIPP in June 1989, at which time a subcommittee was formed to review safety issues in further detail. The WIPP subcommittee was chaired by Dr. Tape (Paul D. Rice, a consultant, chaired the subcommittee until October 1990). Members included Drs. Kastenberg, Lash, Martin, and Seale. Special consultants to the subcommittee included

- Konrad Krauskopf, Stanford University (until October 1990);
- James Ling, Consultant (until October 1990);
- Thomas Pestorius, Consultant;
- Thomas Pigford, University of California, Berkeley (until October 1990);
- Bernard T. Resnick, Consultant; and
- Frank Rowsome, Consultant (until October 1990).

The subcommittee subsequently revisited WIPP and other related facilities: SNL, INEL, and the Rocky Flats Plant. Areas of review included unresolved short-term technical and operational issues and long-term environmental performance. A report to the Secretary was issued by the ACNFS on December 11, 1989 (see CCA Appendix PEER, Section PEER.15) and a final report was issued in November 1991 (see CCA Appendix PEER) for the WIPP chapter of the final report.

The 1989 report identified several recommendations to resolve issues related to both short-term operations and long-term performance of the repository. The final report, titled "Final Report on Department of Energy Nuclear Facilities" (Document PB92-119809), contained a section that dealt with its review of WIPP. This final report contained the following recommendations to "increase the probability of successful compliance with EPA's proposed standards in a shorter period of time . . ."

> Prepare a concise report in a timely manner comparing the expected performance of WIPP with the requirements in EPA's proposed standard (40 CFR 191). This report should specifically focus on those parameters that are currently significantly uncertain and set forth the actions including alternatives, necessary to reduce the uncertainties to acceptable levels for demonstrating regulatory compliance.

> Change current project priorities by putting more emphasis on the use of experts. At this time, panels of experts will provide more significant input to the demonstration of compliance with EPA standards than will the results of the Dry Bin Tests. The Bin Test Program should continue to be focused on reducing uncertainties in those parameters that are most important in determining compliance with EPA's proposed standards.

> Initially dispose only the contact handled TRU waste that will not pose a gas generation problem. Other TRU wastes can be safely stored above ground until it is determined whether they can be buried at WIPP in compliance with regulatory requirements or have to be treated so that disposal at WIPP is acceptable.
>
> Immediately begin development and implementation of engineered alternative, especially for newly generated waste. DOE should be a technological leader in waste management and this initiative should go forward even if it were not specifically required to demonstrate compliance with EPA's proposed standards.

The WIPP project initiated and continued several activities to resolve the ACNFS concerns. Specific action plans were developed and implemented. In June 1990, the DOE prepared a concise report summarizing the current understanding of expected performance and the potential for demonstrating compliance with 40 CFR Part 191, Subpart B (Bertram-Howery and Swift 1990). Preliminary PAs in 1990, 1991, and 1992 identified significant uncertainties and provided guidance to the project. The experimental program was refocused to meet the needs of the compliance evaluation, and the underground bin and alcove tests were canceled. Chapter 4.0, and CCA Appendices WCA and WCL address which wastes will be emplaced at WIPP. The subject of EAs was reviewed by two recent peer review panels (see Sections 9.3.3 and 9.4.4). The ACNFS recommendations were formally closed by the Advisory Committee.

9.4.7 Performance Assessment Review Team

The Performance Assessment Review Team (PART) was organized in 1992 by the DOE's Director of Environmental Restoration and Waste Management WIPP Project Management Division (EM-342). The purpose of the PART review was "to assess the adequacy of the WIPP PA program for meeting relevant regulatory standards for the disposal of radioactive and hazardous wastes, to identify any deficiencies in the program, and to make recommendations for improvements." The team members were as follows:

- Bryan Bower (Chairman), DOE/EM-342;
- Charles Voss (Deputy Chairman), Golder Associates, Inc.;
- James Russell, Texas A&M University;
- Neville Carter, Texas A&M University;
- Pamela Doctor, Pacific Northwest Laboratory; and
- Charles Cole, Pacific Northwest Laboratory.

The group was very knowledgeable of geologic repositories and included specific expertise in PA methodology, brine migration, flow and transport modeling, creep and room closure, and site operations. The review team was not completely independent because the chairman of the review team was a staff member of DOE/EM-342, which had oversight responsibility for WIPP. Section 1.4.1 of the PART report (the complete report is provided in Appendix PEER) states that

> The Director of EM-342 and the PART chairperson selected the PART members on the basis of their knowledge of components and processes associated with salt repository and their independence from the WIPP Project. More specific criteria included (1) familiarity with geologic repositories; (2) PA expertise or knowledge of risk assessment techniques; (3) knowledge of RCRA and/or 40 CFR 191 requirements; and (4) no direct association with any of the PA activities for the WIPP.

Note that the report findings "reflect the consensus of team members" and that the final report was signed by all team members. It was included in this application because of its insight into the PA effort at a pivotal time in the direction of PA for the WIPP project. An evaluation of the PART review against the screening criteria is provided in Table 9-12.

The review was primarily conducted during the first half of 1993 and a final report was issued in February 1994. All PART activities were conducted and documented in accordance with EM-342's NQA-1 based QA program. The PART reviewed the pertinent PA documents and activities, toured the WIPP site, and interviewed members of the project staff. The team concluded that

> The review team finds that the work on the WIPP has generally been perceptive, incisive and fundamentally sound. However, for compliance with current standards and regulations, substantial progress and improvements will be necessary in certain areas where additional investigations and documentation may be required; the PA department is fully aware of most of them. These areas include PA documentation, parameter evaluation, conceptual model justification, time-dependent behavior of natural and engineered barriers to fluid migration from the coupled disposal system, and a total system model.

Considerable effort was made to resolve the concerns identified in this review. The PA process has changed significantly since the PART report to address issues identified in this report, as well as to document the conformance with the requirements of 40 CFR Part 191 and criteria of 40 CFR Part 194. Finally, note that the PART final report was provided to the recent conceptual models peer review panel (see Section 9.3.1) for its consideration. The issue of EAs, as they relate to PA, was specifically reviewed by recent peer review panels (see Section 9.3.3).

9.4.8 INTRAVAL

The INTRAVAL project was initiated in 1987 in Stockholm as an international effort to validate geosphere models for transport of radionuclides. The project was initiated by the Swedish Nuclear Power Inspectorate and was first formed as an ad-hoc group with representatives from eight organizations. By the 1990s, INTRAVAL grew to include 24 "parties" from 14 countries and was coordinated by the Nuclear Energy Authority (NEA) of the Organization for Economic Cooperation and Development (OECD). The INTRAVAL philosophy was to use results from laboratory and field experiments as well as natural analog studies in a systematic study of the model validation process. The goal was to evaluate conceptual and mathematical models for groundwater flow and radionuclide transport in the context of PA of repositories for radioactive waste, with particular focus on the validity of model concepts. The project ended in 1997.

Table 9-12. PART Independent Review of WIPP PA

1. Is the peer review relevant to the CCA?	Yes – the review dealt directly with the PA.
2. Was there a formal report prepared by the reviewer?	Yes – the report is titled "Performance Assessment Team's Independent Review of WIPP Performance Assessment Activities (40 CFR 191 and 40 CFR 268.6) for EM-342." The report is dated February 1994.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the review focused on the adequacy of then current PA and RCRA activities at WIPP.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the review evaluated the adequacy of the work of others.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – Section 1.4.1 states "The Director of EM-342 and the PART Chairperson selected the PART members on the basis of their knowledge of components and processes associated with salt repository and their independence from the WIPP Project. More specific criteria included (1) familiarity with geologic repositories, especially salt; (2) PA expertise or knowledge of risk assessment techniques; (3) knowledge of RCRA and/or 40 CFR 191 requirements; and (4) no direct association with any of the PA activities for the WIPP."
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	No – the team chairman was a DOE EM-342 employee. EM-342 has oversight responsibility for WIPP. The remaining members were university staff and a professional consultant.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Yes – report findings reflect the consensus of team members and the final report was signed by all team members.

A number of test cases were studied at various locations around the world. These test cases included field tests, mining operations, natural analogs, and laboratory experiments. In 1990, two test cases from the WIPP site were included as part of the INTRAVAL investigations, and were designated as WIPP1 and WIPP2. An evaluation of the INTRAVAL project reviews against the screening criteria is provided in Table 9-13. These two test cases are discussed in INTRAVAL Progress Reports (numbers 5 through 10) (see CCA Appendix PEER).

Table 9-13. INTRAVAL

1. Is the peer review relevant to the CCA?	Yes – although not a review of the WIPP project specifically, INTRAVAL used WIPP site characterization data to validate models of groundwater flow.
2. Was there a formal report prepared by the reviewer?	Yes – annual INTRAVAL reports and journal articles provide summaries of the findings.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the two cases discussed provide independent evaluation of the validity of the conceptual models used for Salado brine inflow and Culebra groundwater flow at WIPP.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the two cases evaluated the validity of conceptual models for the WIPP site.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – reviewers were internationally recognized experts in their respective fields. Many had extensive experience in radioactive waste disposal projects in other countries.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – reviewers were not involved in the WIPP project, were impartial, and were free from funding considerations.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

9.4.9 Waste Isolation Pilot Plant Conceptual Model Uncertainty Group Review

The WIPP Conceptual Model Uncertainty Group (CMUG) was an advisory group formed and operated in 1993 to provide guidance to SNL's WIPP PA effort. An evaluation of the CMUG activities against the screening criteria is provided in Table 9-14. A report of their evaluation of the WIPP PA was prepared September 27, 1993 (see CCA Appendix PEER) and is summarized below.

Table 9-14. Conceptual Model Uncertainty Group

1. Is the peer review relevant to the CCA?	Yes – the CMUG reviewed the 1992 conceptual models used for PA.
2. Was there a formal report prepared by the reviewer?	Yes – meeting summaries were prepared.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – it was a review of the adequacy of the WIPP conceptual models.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Partially – although the CMUG reviewed the existing PA models, its primary thrust was to recommend improvements in the models.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – group members are internationally recognized experts in their respective fields.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the recommendations were provided from an independent and impartial perspective.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Yes – the review conducted a detailed review of the WIPP conceptual models and provided extensive comment on those models.

The CMUG included expertise in hydrology, geology, geochemistry, risk assessment, and environmental modeling. All committee members were consultants who, at that time, worked outside the SNL community. The panel members were as follows:

- Craig Bethke, University of Illinois;
- Rafael Bras, Massachusetts Institute of Technology;
- Jesus Carrera, Universidad Politechnica de Catluta;
- Neil Chapman, Intera Information Technologies Ltd.;

- Ghislain de Marsily, University Pierre et Marie Curie;
- Daniel Galson, Galson Sciences Ltd.;
- Steven Gorelick, Stanford University;
- Jane Long, Lawrence Berkeley Laboratory; and
- Dennis McLaughlin (Chairman), Massachusetts Institute of Technology.

The charter of the CMUG states

> The conceptual model uncertainty ... group is being formed to provide guidance to the WIPP PA program on how to account for uncertainty associated with conceptual models for the groundwater flow and radionuclide transport systems in the Rustler and other non-Salado formations.

The group was also asked to "... help ... on the development of alternative conceptual models and treatment of conceptual model uncertainty ..."

During its first two meetings in March and October of 1993, the CMUG focused on gaps, ambiguities, questionable assumptions, and simplifications that should be resolved before a final PA is submitted. The CMUG's initial reaction was that the WIPP PA has concentrated too much on simulation exercises and too little on identifying potential pathways and processes. They recommended that the PA should devote more effort to understanding the origins and evolution of the non-Salado environment, particularly its geology, geochemistry, and hydrology. Specific concerns were provided in four areas: (1) regional hydrology, recharge, and the effects of climate change; (2) geologic history, evolution, and structure over a range of scales; (3) geochemical evolution and composition of groundwater; and (4) alternative transport pathways. These concerns are documented in the CMUG report, which is provided in CCA Appendix PEER.

Most of the recommendations provided by the CMUG were implemented. In direct response to the CMUG recommendations, an in-house working group was formed in the spring of 1993 to reevaluate conceptual models for use in PA. That group contained representatives of both PA and experimental activities, and made significant progress during the remainder of 1993 in redefining PA conceptual models. The DOE performed a complete rescreening of all FEPs as part of the preparation of this application. CMUG concerns were addressed as part of this activity. Also, the CMUG reports were provided to the CMPR panel (see CCA Section 9.3.1) for consideration in its assessment of the WIPP PA conceptual models.

9.4.10 Environmental Evaluation Group Reviews

The EEG was established in 1978 as an independent technical advisory group to assist in the State review of the WIPP project. The EEG continues to be funded by the DOE through the New Mexico Institute of Mining and Technology.

The following is a list of the EEG staff members and their technical disciplines in October 2003:

- Matthew Silva (Director), Chemical Engineer;

- James Channell (Deputy Director), Environmental Engineer;
- Larry Allen, Geologic Engineer;
- George Anastas, Health Physicist /Nuclear Engineer;
- Sally C. Ballard, Radiochemical Analyst;
- Radene Bradley, Secretary;
- Patricia Fairchild, Secretary;
- Don H. Gray, Laboratory Manager;
- John Haschets, Assistant Environmental Technician;
- Linda Kennedy, Librarian;
- Lanny King, Environmental Technician;
- Tom Klein, Environmental Scientist;
- Jill Shortencarier, Executive Assistant;
- Susan Stokum, Administrative Secretary;
- Ben A. Walker, QA Specialist;
- Scott Webb, Health Physicist II; and
- Judith F. Youngman, Administrative Officer.

The EEG conducts independent technical analyses of numerous aspects of the WIPP project. These analyses include assessments of reports issued by the DOE and its contractors as they relate to the potential health, safety, and environmental impacts from the WIPP. The EEG also performs independent environmental monitoring of background radioactivity in air, water, and soil, both on- and off-site.

The EEG has published 86 reports relating to numerous aspects of the WIPP project since 1978. An evaluation of the EEG reviews against the screening criteria is provided in Table 9-15. When evaluated against the screening criteria, it was determined that most of the reports (and associated work) involved issues outside the scope of this application and/or appear to represent expert judgment or technical review. However, 15 of the reports published

Table 9-15. EEG Reports

1. Is the peer review relevant to the CCA?	Some of the reports address site characterization and other CCA issues.
2. Was there a formal report prepared by the reviewer?	Yes – EEG prepares and publishes formal reports.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Some of the reports fit the NUREG-1297 definition of peer review.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Some of the reports review the adequacy of the work of others.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the EEG is recognized as an expert group.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – EEG was created to provide an independent technical review of WIPP.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Only those reports which pass the above criteria will be incorporated into the CCA.

before the submission of the CCA appeared to qualify as peer reviews, per NUREG-1297, and address issues relevant to the compliance certification application. Those 15 reports were discussed in CCA Chapter 9 and are mentioned by titles and authors only in this chapter. The EEG has published 25 additional reports since August 1996, EEG-62 to EEG-86. Out of these, 11 reports (EEG-62, 64, 66, 68, 69, 75, 77, 82, 83, 85, and 86) appear to qualify as peer reviews, per NUREG-1297, and address issues relevant to the CRA-2004. Each of these 11 reports is discussed below.

The issues and concerns raised by EEG have been continually evaluated by the WIPP project. A considerable amount of additional testing and analysis have been undertaken because of EEG's involvement, and substantial changes have occurred in the WIPP project as a result.

9.4.10.1 EEG-2 (1978): Review Comments on the GCR, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico, SAND78-1596, Volumes I and II

See CCA Chapter 9 for a summary of this report.

9.4.10.2 EEG-3 (1979): Radiological Health Review of the Draft Environmental Impact Statement (DOE/EIS-0026-D) Waste Isolation Pilot Plant, U.S. Department of Energy

See CCA Chapter 9 for a summary of this report.

9.4.10.3 EEG-8 (1980): The Significance of Certain Rustler Aquifer Parameters for Predicting Long-Term Radiation Doses from WIPP

See CCA Chapter 9 for a summary of this report.

9.4.10.4 EEG-9 (1981): An Approach to Calculating Upper Bounds on Maximum Individual Doses from the Use of Contaminated Well Water Following a WIPP Repository Breach

See CCA Chapter 9 for a summary of this report.

9.4.10.5 EEG-10 (1981): Radiological Health Review of the Final Environmental Impact Statement, (DOE/EIS-0026), Waste Isolation Pilot Plant, U.S. Department of Energy

See CCA Chapter 9 for a summary of this report.

9.4.10.6 EEG-11 (1982): Calculated Radiation Doses from Radionuclides Brought to the Surface If Future Drilling Intercepts the WIPP Repository and Pressurized Brine

See CCA Chapter 9 for a summary of this report.

9.4.10.7 EEG-12 (1982): Potential Release Scenario and Radiological Consequence Evaluation of Mineral Resources at WIPP

See CCA Chapter 9 for a summary of this report.

9.4.10.8 EEG-22 (1983): EEG Review Comments on the Geotechnical Reports Provided by DOE to EEG Under the Stipulated Agreement Through March 1, 1983; and EEG-23 (1983): Evaluation of the Suitability of the WIPP Site

See CCA Chapter 9 for summaries of these reports.

9.4.10.9 EEG-29 (1985): Evaluation of the Safety Analysis Report for the Waste Isolation Pilot Plant Project

See CCA Chapter 9 for a summary of this report.

9.4.10.10 EEG-40 (1989): Review of the Final Safety Analysis Report (Draft), DOE Waste Isolation Pilot Plant

See CCA Chapter 9 for a summary of this report.

9.4.10.11 EEG-41 (1989): Review of the Draft SEIS, DOE Waste Isolation Pilot Plant, April 1989

See CCA Chapter 9 for a summary of this report.

9.4.10.12 EEG-50 (1992): Implications of Oil and Gas Leases at the WIPP on Compliance with EPA TRU Waste Disposal Standards

See CCA Chapter 9 for a summary of this report.

9.4.10.13 EEG-57 (1994): An Appraisal of the 1992 Preliminary Performance Assessment for the Waste Isolation Pilot Plant

See CCA Chapter 9 for a summary of this report.

9.4.10.14 EEG-61 (1996): Review of the WIPP Draft Application to Show Compliance with EPA TRU Waste Disposal Standards

See CCA Chapter 9 for a summary of this report.

9.4.10.15 EEG-62 (1996): Fluid Injection for Salt Water Disposal and Enhanced Oil Recovery as a Potential Problem for the WIPP: Proceedings of a June 1995 Workshop and Analysis, by Matthew K. Silva (Silva 1996)

The following is a summary of the EEG report (EEG-62) and therefore represents the views of the EEG and not necessarily those of DOE.

The potential impact of brine injection on the long-term performance of the WIPP prompted the EEG to organize a June 13, 1995 workshop on the issue. This report publishes the workshop presentations and presents the author's analysis of the workshop issues based on information from the scientific literature, public records, the draft compliance application submitted by the DOE to the U.S. EPA, and the WIPP-specific compliance criteria promulgated by the EPA. The workshop included presentations describing the extent of oil and gas resources, the anomalous water level rises in the Culebra Aquifer, the documented effects of water flooding on the Salado, the geology of waterflooded areas in southeast New Mexico, the current petroleum production practices, the treatment of water injection by the PA effort, and the need for a water flooding scenario in the WIPP PA calculations.

The issues identified include questions about (1) the productive life of an oil field in the Delaware Basin, (2) the extent of oil and gas reserves in unexplored areas, (3) the potential for waterflooding and other secondary recovery methods, (4) the volumes of water to be injected, (5) the availability of water for waterflooding, (6) delays in oil and gas drilling due to the presence of potash, (7) the true extent of potash reserves, (8) evidence of communication between formations above and below the WIPP through vertical pathways possibly created by the improper abandonment of wells, poorly cemented and cased wells, degraded well casings and cement in saline environments, and (9) violation of existing regulations.

In response to the recommendations in this report, the DOE considered fluid injection as a scenario in the PA included in the CCA. The EPA accepted the DOE arguments and analysis (See EPA Docket A-93-02, Item II-I-1, Attachment 2 and Items II-1-9, II-1-7, II-1-25, II-1-27, II-1-32, and II-1-37).

9.4.10.16 EEG-64 (1997): Review of the Draft Supplement to the WIPP Environmental Impact Statement DOE/EIS-0026-S-2, by Robert H. Neill, James K. Channell, Peter Spiegler, and Lokesh Chaturvedi (Neill et al. 1997)

The following is a summary of the EEG report (EEG-64) and therefore represents the views of the EEG and not necessarily those of DOE.

EEG's review of the WIPP Disposal Phase Draft Supplemental Environmental Impact Statement (SEIS-ll) concentrated on the radiological aspects of the proposed action, including transportation. The alternatives were reviewed in less detail. Some calculations were checked, mostly for the proposed action. Because of time constraints, there was little review of hazardous chemicals, economics, or other environmental assessments.

EEG stated that compared to the proposed action, the proposed alternatives dealt with larger volumes of TRU waste continued over a much longer period of time, and were evaluated in a less rigorous manner. According to EEG, there was a need for real options to dispose of TRU wastes not included in the WIPP statutory limits.

EEG checked the transportation calculations in Appendix E of SEIS-II and compared these results to those contained in EEG-46. EEG concluded that the assessment of transportation risks in SEIS-II is reasonable and adequately conservative.

Analyses in SEIS-II indicated potential advantages to using rail rather than truck transportation for wastes. The rail analyses were not as rigorous as those for truck transportation. However, the findings were consistent with analyses in the FEIS, SEIS-I, and other documents. EEG recommended that DOE should take this opportunity to seriously reevaluate the merits of a "truck/rail mix" or a "maximum rail" policy for WIPP wastes.

9.4.10.17 EEG-66 (1998): Individual Radiation Doses from Transuranic Waste Brought to the Surface by Human Intrusion at the WIPP by James K. Channell and Robert H. Neill (Channell and Neill 1998)

The following is a summary of the EEG report (EEG-66) and therefore represents the views of the EEG and not necessarily those of DOE.

The EPA standards 40 CFR Part 191 require the DOE to evaluate the effects of releases from the repository for both undisturbed and disturbed conditions. Releases from undisturbed events must be evaluated for the radiation dose to individuals (§191.15) and the effect on groundwater quality (§191.24), as well as for the cumulative release of TRU to the accessible environment. Most other countries with nuclear waste require that radiological risk to an individual be assessed for both undisturbed and disturbed scenarios.

The specific purpose of this report was to:

1. Calculate likely individual doses that would result from the same releases predicted by the CCA,

2. Determine whether these calculated doses exceed limits for radiation exposure from other activities,

3. Compare the stringency of an individual dose standard at WIPP with the release limits in 40 CFR Part 191, and

4. Discuss the appropriateness and feasibility of reducing potential doses to an individual from human intrusion at WIPP.

The deterministic calculations in this report rely primarily on drilling-related analyses in the CCA to determine the source term. Details of the scenarios for workers, individual members of the public, and the population within 80 kilometers (50 miles) of the site are adapted from scenarios in prior WIPP reports. Pathway analyses and dose conversion factors primarily use current methodology from EPA and NRC reports.

There are inherent uncertainties in estimating repository conditions, human actions, and individual doses at WIPP over a 10,000-year period. With this caveat, the report reached the following conclusions.

- Calculated doses to drillers and the resident farmer exceeded annual dose limits for occupational radiation workers only for the low-probability scenarios at the 100-year intrusion time.

- Calculated doses to drilling crew members and the resident farmer exceeded 100 mrem (1 mSv) y^{-1} at the 95 percent probability level. This is greater than the limits allowed in other standards regulating radioactive material, waste disposal, and contaminated site cleanup.

- Calculated doses to the resident non-farmer and the non-resident farmer (for the 95 percent probability release) are greater than the 500-mrem (5 mSv) y^{-1} value NRC used for similar scenarios in establishing low-level radioactive waste concentration limits in 10 CFR Part 61.

- Health effects predicted from a very preliminary integrated collective dose calculation are less than, but within an order of magnitude of, the health effects implied from 40 CFR Part 191 for the amounts released in the CCA.

- An individual dose limit of 100 mrem (1 mSv) y^{-1} (at 95 percent probability level) to the resident farmer at WIPP would be an order-of-magnitude more restrictive than the cumulative release limit in 40 CFR 191. Releases predicted in the CCA would be less than the 100 mrem (1 mSv) y^{-1}limit but releases predicted in the PAVT would be > 100 mrem (1 mSv) y^{-1}.

- Since individual doses can be substantial, DOE should use ALARA designs (such as treating the waste) to limit these doses.

9.4.10.18 <u>EEG-68 (1998): Evaluation of the WIPP Project's Compliance with the EPA Radiation Protection Standards for Disposal of Transuranic Waste by Robert H. Neill, Lokesh Chaturvedi, Dale F. Rucker, Matthew K. Silva, Ben A. Walker, James K. Channell, and Thomas M. Clemo (Neill et al. 1998)</u>

This report provided the EEG's technical evaluation of the CCA and the EPA's proposed rule to certify WIPP (EPA 1997). The full report is included in Appendix PEER-2004.

The rest of the text in this section contains a summary of the EEG report (EEG-68) and therefore represents the views of the EEG and not necessarily those of DOE.

9.4.10.18.1 Solubility

The solubility of actinides is very important to calculating the releases from the repository. The CCA uses a model known as Fracture-Matrix Transport (FMT) to calculate these solubilities. EEG found that the model predicts differences for actinide sulfate solubilities that cannot be explained by chemistry, thus raising questions about the reliability of this model.

Rather than using an extensive plutonium database, the FMT predictions relied on thermodynamic data for other elements and an oxidation state analog argument. EEG recommended that the calculations be performed using data for plutonium and the values for solubility and complex ion formation contained in the peer-reviewed data compilation by the NEA/OECD.

EEG agreed with EPA's documentation of the shortcomings of the solubility uncertainty ranges advanced by DOE. However, EEG questioned EPA's argument that the ranges are adequate. As noted by EPA, there is a lack of data to determine the uncertainty ranges for oxidation states IV and VI. EEG recommended that the uncertainty range needed to be determined with the appropriate plutonium data.

According to EEG, in the solubility calculations, the CCA inappropriately discounted the role of organic ligands on plutonium solubility by arguing that EDTA is the strongest complexing agent and there is not enough present in the inventory to make a difference. But, EEG argued, citrate forms very strong complexes with actinides in the +4 oxidation state and very weak complexes with other cations. Thus, the solubility of a stable plutonium-citrate complex in individual waste containers needed to be calculated.

EEG claimed that there are serious unanswered questions about the impact of MgO backfill on the solubility of the actinides. It is proposed that MgO will reduce the solubility of the actinides by controlling the pH. However, it is not known how long the early reaction product, nesquehonite, would persist. The FMT model calculates that the presence of nesquehonite drives the solubility of the +4 actinides, such as Pu, higher than in the no-backfill case. EEG suggested that this required further investigation.

9.4.10.18.2 Spallings

The EEG stated that the CCA spallings model was rejected by the DOE's peer review after submission of the CCA, but a new coherent model and a computer code that calculates the projected releases had not been developed. The EEG found the basis of accepting the predicted release volumes due to spallings as determined by the CCA to be both unnecessarily convoluted and faulty. EEG argued that since this is a mechanism for the largest projected releases from the repository, it is essential that it be treated through defensible conceptual and numerical models.

9.4.10.18.3 Air Drilling

The EEG stated that the air drilling scenario proposed by Dr. John Bredehoeft was rejected on the basis of regulation, despite records of such drilling in the Delaware Basin. Low probability and low consequence are also discussed in EPA's Air Drilling Analysis (EPA 1998c), and the scenario was ruled out again. However, the EEG did not believe that the issue had been resolved. Neither EPA nor DOE examined drilling records in the Texas portion of the Delaware Basin. New developments in underbalanced drilling also inhibit a full understanding of the capabilities of this expanding technology. According to EEG, the EPA's analysis of low consequence, in which a spreadsheet model was used, had serious shortcomings.

9.4.10.18.4 Fluid Injection

According to EEG, for fluid injection activities adjacent to the site, the EPA had accepted a "low consequence" argument based on a model that had not been verified with oil field water flood data, despite the availability of such data. According to EEG, EPA offered a low probability argument based on its expectations of fluid injection practices, although DOE maintained that the probability of future fluid injection practices would be difficult to define. The low probability argument had not been reconciled with the common observation of water flowing through the Salado in water flood operations throughout southeast New Mexico. Further, according to EEG, neither the DOE nor the EPA had adequately addressed concerns about future CO_2 flooding in the vicinity of WIPP. The basis for dismissing the Rhodes-Yates incident did not reflect a review of the technical information presented in that case. DOE had not explained the anomalous water level rises observed for the last 10 years in the Culebra aquifer despite the documented concerns of EEG, EPA, and the NAS WIPP Committee. EEG recommended additional effort to explain the Rhodes-Yates water flooding incident. The EEG maintained that the fluid injection scenario could not be dismissed either on the basis of low consequence or low probability.

9.4.10.18.5 Anhydrite Fracturing

The EEG had a number of questions about the validity of the anhydrite fracture model used in the BRAGFLO code. The EEG stated that the model was unusual in that the effect of fracturing was treated using an equivalent porous medium. All the relevant literature examined by EEG treated fractures as distinct porosity. Use of an equivalent porous medium is not in itself unreasonable; however, the DOE had not referenced a description of similar treatment of the dependence of porosity and permeability on pressure as a result of fracturing. The lack of a clear development of the BRAGFLO model from established models made its review difficult. The EPA should request that the anhydrite fracture model of BRAGFLO be compared to the treatment of fracture development in hydrofracing codes commonly used in the industry. According to EEG, until the model and its assumptions were properly justified, the EEG found it difficult to accept the results derived from this model.

9.4.10.18.6 Solution Mining

EEG stated that the EPA's conclusion that potash solution mining was not likely at WIPP relied on solicited comments that were factually incorrect and inconsistent with the published scientific literature. DOE and EPA maintain that excavation mining captures the effects of solution mining on the hydraulic conductivity of the overlying aquifers. However, according to EEG, the prediction of subsidence above solution mines can be much more complex than the prediction of subsidence due to excavation mining. According to EEG, it appeared incorrect to calculate mining probability based on past potash production, which was inherently dependent on past mineral economics and the availability of high-grade ore. EEG argued that potash is used by the fertilizer industry and is ultimately used for the production of food. It seemed reasonable to EEG to assume that the demand for food would continue and low-grade potash ores would eventually be mined to meet this demand.

9.4.10.18.7 Groundwater Flow and Radionuclide Transport through the Culebra

EEG stated that a number of questions related to the flow and transport through the Culebra had been identified by the EEG that were not addressed by the EPA. These questions relate to the conceptual models of the origin and flow of water in the Culebra aquifer, transport modeling through the Culebra, and justifying the assumed values of the chemical retardation parameter (K_d) in the CCA calculations.

9.4.10.18.8 BRAGFLO 2D/3D Modeling

According to EEG, the results of the DOE's screening analysis for repository processes (FEP S-1) suggest that the 2D BRAGFLO model used in the CCA calculations may misrepresent repository performance at pressures above the anhydrite fracture pressure. There is the potential of substantially greater brine saturation in the repository at higher pressures than calculated for the CCA. The discrepancy between the 2D and 3D versions of BRAGFLO may have underestimated radionuclide releases to the surface. To resolve this issue, the EEG recommended that several three-dimensional (3D) BRAGFLO simulations of the repository should be performed using the parameter values of vectors used in the CCA PA. The 3D BRAGFLO simulations should be used to provide repository conditions for the normal suite of DBR calculations. The calculations should also be assessed in terms of impact on spallings calculations.

The DOE and EEG held a meeting on February 17, 1998 to try and resolve this issue. It was agreed at that meeting that there was sufficient reason to further investigate the potential for greater brine inflow to the repository using 3D modeling compared to the calculated value using the 2D model of the CCA. It was agreed that a simulation corresponding to a parameter vector that led to high pressure and anhydrite fracturing in the CCA calculations would be sufficient to demonstrate the potentially increased brine inflow compared to the CCA calculation.

9.4.10.18.9 Brine Reservoirs

The EEG raised a number of issues related to the Castile Formation brine reservoirs in commenting on the CCA. The EPA accepted all the EEG suggestions except one related to the assumption of the probability of encountering brine reservoirs. EEG disagreed with the EPA on this issue. The CCA assumed an eight percent probability on the basis of faulty assumptions. The EEG recommended a 100 percent probability on the basis that the WIPP-12 brine reservoir was large enough to most likely extend under the repository. The EPA sampled on a range of 1 to 60 percent, but, according to EEG, provided no basis for assuming less than 60 percent. Based on the arguments that the geophysical (time-domain electro-magnetic survey) data may be interpreted to indicate the brine to be under 60 percent of the repository, and that some boreholes adjacent to the brine-producing boreholes are known to be dry, the EEG was willing to accept the assumption of a fixed 60 percent probability of encounter, and recommended that a new PA calculation be run with that fixed value.

9.4.10.18.10 Waste Issues

DOE calculations showed that nonrandom emplacement of radionuclides in the repository led to significantly higher releases from cuttings and cavings and spallings. EEG recommended that revised calculations should be incorporated into the CCDF even though partial sensitivity analyses indicate that nonrandom emplacement would not, in itself, result in noncompliance.

EEG also stated that the expected quantity of cellulosics, rubber, and plastic (CRP) materials in the repository was slightly greater than the waste repository limit and that the ability to characterize CRP waste with sufficient accuracy had not been shown. EEG recommended that the limit should be controlled on a per-panel basis rather than for the entire repository.

9.4.10.18.11 Assurance Requirements

There are six assurance requirements in the EPA standards (40 CFR 191) that were incorporated to provide additional confidence in the repository because of the inherent uncertainty in projecting the future behavior of natural systems and inadvertent human action. The EEG agreed with the EPA determination of two of these six requirements, the active and the passive institutional controls, but had questions about the other four. According to EEG:

1. The monitoring plan did not appear to meet the intent of the standards.

2. DOE's retrieval plan and the EPA's determination of its compliance with the requirement appeared to give a false sense of security regarding the retrievability of waste.

3. WIPP did not appear to meet the intent of the resource disincentive requirement. EEG argued that this is another reason for additional engineered barriers to be incorporated in the WIPP design for making the waste less respirable and soluble through treatment and repackaging. Since DOE had plans to treat or repackage 85 percent of the existing CH-TRU waste anyway, EEG argued, this recommendation should be easy to implement.

9.4.10.18.12 Individual Protection Requirements

Although EEG had minor disagreements about several DOE assumptions in evaluating the Individual Dose Requirements, they agreed that compliance with these requirements had been demonstrated.

9.4.10.18.13 Environmental Standards for Ground water Protection

EEG believed there was a very low probability of significant Underground Source of Drinking Water (USDW) contamination by an undisturbed release. However, EEG stated that 40 CFR 191.24 specifies that no contamination is permitted if the USDW is initially at or above the radionuclide limits of 40 CFR 141. Therefore, EEG recommended submitting data showing the USDWs were below allowed limits or that there was a zero probability of any contamination reaching the USDW.

The EPA gave serious consideration to all the comments in this report. Their responses were provided in the EPA's Response to Comments (EPA 1998b).

9.4.10.19 EEG-69 (1998): Sensitivity Analysis of Performance Parameters Used in Modeling the WIPP by Dale F. Rucker (Rucker 1998)

The following is a summary of the EEG report (EEG-69) and therefore represents the views of the EEG and not necessarily those of DOE.

This report contains the results of sensitivity analysis on the WIPP PA performed by EEG by changing selected values or the range of selected values that were used in the CCA. This type of sensitivity analysis would distinguish the important parameters of repository performance, while testing the robustness of the codes involved. The analysis also allowed for the testing of the limit to which the disposal system would fail under extreme conditions. This is also useful in characterizing the important parameters. The results are briefly described below. The full report is included in Appendix PEER-2004.

9.4.10.19.1 Borehole Intrusion Rate

The consequence of future human intrusion scenarios into the WIPP was investigated in the CCA, as required by EPA in 40 CFR Part 194 (EPA 1996b), and included the possibility of mining and deep and shallow drilling for resources.

The 40 CFR Part 194.33 criteria state that the likelihood of a drilling intrusion into the Delaware Basin be calculated by considering the frequency of drilling over the past 100 years for all resources and using that rate for the 10,000-year future of the WIPP. A total of 46.8 boreholes per km^2 per 10,000 years were estimated based on past drilling of resources at depths greater than 655 m (2150 ft), which equal 10,804 boreholes per century in 23,102.1 km^2 (14,439 mi^2) (area of Delaware Basin).

The above drill intrusion rate for the 10,000-year future of the WIPP was used by DOE in the CCDFGF model. Due to the uncertainty in predicting future human activities, the effect of altering this rate on the CCA calculations has been assessed in this report.

The modeling associated with an increased borehole rate shows that a factor of approximately 23 is needed to reach the EPA release limit at a probability of 10^{-1} from values used in the CCA. The overall mean for the highest release tested at 0.468 boreholes/km^2/yr (1.2 boreholes/mi^2/yr) exceeds 10 EPA unit limit at the 10^{-3} probability on the CCDF curve. This high rate of borehole intrusion, however, does not seem likely, as the number of boreholes drilled in the Delaware Basin in 10,000 years would have to exceed 1,000,000 per century, or 4,680 boreholes per km^2 (11,981 boreholes per mi^2) per 104 years.

9.4.10.19.2 Probability of Brine Encounter at WIPP

The probability of encountering brine at the WIPP from an intrusion into a Castile brine reservoir is uncertain. The parameter describing the probability was set to eight percent in the CCA, and changed to a range of probabilities from 1 percent to 60 percent in the EPA's PAVT. Since the extent of the reservoir beneath the WIPP is unknown, the influence of this parameter was tested at higher values at 50 percent and 100 percent. These values were based on the potential that the Castile brine reservoir encountered by WIPP-12 extends below the waste area.

The modeling presented in this report only compared CCA release values to the proposed higher probability of encounter, and found the parameter to be unimportant in the CCA. The increase in releases from the 8 percent to 100 percent was only 0.1 EPA units (35 Ci).

9.4.10.19.3 Castile Brine Reservoir Parameters

The reservoir parameters used in the CCA were derived from borehole information that is mainly outside the domain of the WIPP repository. The borehole distances ranged from 6 km (3.75 mi) to over 17.7 km (11 mi) from the repository center. New values were assigned to several parameters that describe a Castile brine reservoir based on WIPP-12 data more closely identified to the conditions at the repository.

The parameters associated with describing a Castile brine reservoir include reservoir volume, rock compressibility, reservoir pressure, and permeability. Assuming an inadvertent human intrusion, modeling of these parameters began with the two-phase flow code, BRAGFLO, and ended with calculations of solid and liquid waste released to the accessible environment. The outcome showed that there is no significant change in releases for the CCDF due to small changes in the reservoir parameters.

9.4.10.19.4 Solubility Modeling of Actinides

The results of the EEG analysis showed that increases in solubility using CCA brine release volumes had limited effect on compliance, with an overall increase on the mean CCDFs by 0.09 EPA units. Even when the solubility was increased to absurdly high values, the maximum release was limited by the availability of the actinide source. At a solubility of 8×10^{-3} M (compared to the CCA's 4.4×10^{-6} M for Pu+4 in Salado brine), the overall mean for DBR was increased from 0.04 to 1.3 EPA units.

Bounding calculations were performed on conditions resulting in the highest solubilities in the repository. These included nesquehonite and no backfill. For the nesquehonite simulations, it was assumed that the mineral would persist for the entire proposed history of the repository.

Only median solubility values were used, as opposed to the CCA, which generated a set of expected values from a range of -2 to +1.4 orders of magnitude from the median to capture the uncertainty. The assumption of the intermediate species being long-lived overestimates the expected conditions, and the EEG does not suggest that MgO should not be used as a backfill material. The models were established to better understand the performance of the repository.

The consequences of higher solubilities were quite high. The overall mean release for the CCA and PAVT were 0.2 and 0.4 EPA units at 10^{-3} probability, respectively. The overall mean for the increased solubilities of nesquehonite and no backfill are 6.0 and 8.0 EPA units at the 10^{-3} probability, respectively. The limit for compliance, according to 40 CFR Part 194, is 10 EPA units. While these calculations, based on DOE's own solubility values, do not violate the containment requirements, they show that there is little margin for error.

9.4.10.19.5 Flow and Transport Modeling within the Culebra

The EEG's concern in the Culebra modeling related to actinide sorption (K_d values), limitations in assumed future mining, and actinide solubility values assumed. The effects of extended mining, low K_ds, and high solubilities were combined in an effort to test the synergistic effect of all the previous results. The overall mean for the release through the Culebra was as high as one EPA unit (or 344 Ci) at a 10^{-3} probability of release. The addition of the Culebra releases to the overall mean of all combined releases moved the CCDF closer to the EPA compliance limit by 12 percent, but did not show noncompliance.

The EPA gave serious consideration to all the comments in this report. The responses were provided in the EPA's Response to Comments (EPA 1998b).

9.4.10.20 EEG-75 (1999): Evaluation of Risk and Waste Characterization Requirements for the Transuranic Waste Emplaced in WIPP during 1999 by James C. Channell and Ben A. Walker (Channell and Walker 2000)

The following is a summary of the EEG report (EEG-75) and therefore represents the views of the EEG and not necessarily those of DOE.

Section IV.B.2.b of the RCRA permit from the NMED contained language that appeared to prohibit placement of non-mixed wastes that were not characterized in accordance with the requirements of the permit's Waste Analysis Plan (WAP). The justification for adding Section IV.B.2.b was that mixing WAP-certified wastes with pre-permit wastes created unknown risks that should not be a part of permit performance standards. Statements were made during permit public hearings and in written testimony that the risks might be substantial, but there was no indication of the nature of these risks or their magnitude.

This report provides a technical evaluation, conclusions, and recommendations of the following Section IV.B.2.b issues:

- A comparison of pertinent WAP requirements with pre-permit waste characterization;
- A risk analysis of the pre-permit waste emplaced in Room 7. Expected and bounding risks from routine operations and possible accidents are evaluated.

9.4.10.20.1 Conclusions

1. The NMED-approved WAP has made explicit many of the undocumented assumptions and implied good practices from the DOE's pre-permit waste characterization program. Although there are differences between the pre-permit and WAP characterization programs, the pre-permit program appears to substantially meet the technical requirements in the WAP.

2. Deviations granted by DOE during pre-permit waste characterization and premature closures of some corrective actions generated during independent audits may be the most significant differences from the permit waste characterization requirements.

3. Estimated carcinogenic risks to an underground worker, a surface worker, and a member of the public due to routine operations from all the TRU wastes emplaced in Room 7 in 1999 are 6 to 8 orders of magnitude less than risk levels allowed by the permit. Noncarcinogenic risks are 7 to 10 orders of magnitude below allowed risks.

4. Even if volatile organic compound (VOC) emissions are much higher than risk calculations estimate, the Confirmatory VOC Monitoring Plan in use at WIPP would detect concentrations that are three orders of magnitude below allowable permit limits.

5. Risks to the surface worker and member of the public from low-probability accidents are essentially all from radionuclide releases and are lower than the allowable permit risks from routine VOC releases. Risk to the underground worker is significant (1.7×10^{-3} if the accident occurs).

9.4.10.20.2 Recommendations

Questionable data for the individual container lots of pre-permit waste could be reviewed by NMED for conformance with the WAP requirements, if necessary. This determination should consider all deviations and include input from the DOE.

The calculated nonaccidental risks from the pre-permit waste in Room 7 are too low to justify any remedial or other actions involving these wastes.

Radionuclide risks to underground workers from low-probability spontaneous fire and roof-fall accidents should be considered when setting restrictions on worker access to the south 1600 and east 300 drifts.

DOE and NMED have successfully resolved these issues.

9.4.10.21 EEG-77 (2000): Plutonium Chemistry Under Conditions Relevant for WIPP Performance Assessment: Review of Experimental Results and Recommendations for Future Work by Virginia Oversby (Oversby 2000)

The following is a summary of the EEG report (EEG-77) and therefore represents the views of the EEG and not necessarily those of DOE.

This report reviewed the issues related to the chemistry of Pu as it may affect the potential for release of radioactivity from the WIPP repository after closure. Emphasis was placed on conditions appropriate for the human intrusion scenario(s), since human intrusion has the largest potential for releasing radioactivity to the environment under WIPP conditions. According to the author, the most significant issues that need to be addressed in relation to Pu chemistry under WIPP conditions are (1) the effects of heterogeneity in the repository on Pu concentrations in brines introduced under the human intrusion scenario, (2) the redox state of Pu in solution and potential for Pu in solid phases to have a different redox state from that in the solution phase, (3) the effect of organic ligands on the solubility of Pu in WIPP-relevant brines, and (4) the effects of TRU-waste characteristics in determining the solubility of Pu. These issues are reviewed with respect to the treatment they received in the CCA (DOE 1996a), DOE's response to EEG's comments on the CCA, and EPA's response to those comments as reflected in the final EPA rule that led to the opening of the WIPP (EPA 1998a). Experimental results obtained in DOE's Actinide Source-Term Test Program (STTP) during the last two years are reviewed and interpreted in the light of other developments in the field of Pu solution chemistry. This analysis is used as the basis for a conceptual model for Pu behavior under WIPP conditions.

This report identifies three issues that, according to the author, can be addressed as part of the five-year recertification cycles. First, the impact of organic ligands on the complexation of a system with multiple cations could be delineated by some simple experiments with thorium (Th) (IV), citrate, EDTA, Ca^{2+}, and one or more transition metals. An experiment with Pu (IV) could be designed to determine the liability of Pu oxidation states in the presence of organic ligands. Second, the issue of using analogs for Pu could be addressed with appropriate experiments using uranium (U) and Pu at redox conditions in the range anticipated at the WIPP. Attention to the published experimental results of U and Pu could make a considerable contribution to this effort. Third, the issue of uncertainty in calculated actinide solubility can be resolved with experimental data for Pu (IV) compounds of appropriate compositions. The report also recommends starting by constructing a database for U and Pu using the published, peer-reviewed NEA/OECD U and Pu databases.

These issues are addressed in CRA-2004 and will continue to be addressed in future recertifications.

9.4.10.22 EEG-82 (2001): Evaluation of Proposed Panel Closure Modifications at WIPP by Lawrence E. Allen, Matthew K. Silva, James K. Channell, John F. Abel, and Dudley R. Morgan (Allen et al. 2001)

The following is a summary of the EEG report (EEG-82) and therefore represents the views of the EEG and not necessarily those of DOE.

A key component in the design of the WIPP repository is the installation of concrete structures as panel seals in the intake and exhaust drifts after a panel has been filled with waste containers. As noted in the EPA final rule, the panel seal closure system is intended to block brine flow between the waste panels at the WIPP. On April 17, 2001, the DOE proposed seven modifications to the EPA concerning the design of the panel closure system.

EPA approval of these modifications is necessary since the details of the panel design are specified in EPA's final rule as a condition for WIPP certification. However, the EPA has not determined whether a rulemaking would be required for these proposed design modifications. On September 4, 2001, the DOE withdrew the request, noting that it would be resubmitted on a future date.

The EEG contracted with two engineers, Dr. John Abel and Dr. Rusty Morgan, to evaluate the proposed modifications. The EEG has accepted the conclusions and recommendations from these two experts:

1. replacement of SMC with a generic salt-based concrete,
2. replacement of the explosion wall with a construction wall,
3. replacement of freshwater grouting with salt-based grouting,
4. allowing surface or underground mixing, and
5. allowing up to one year for completion of closure.

The proposed modification to allow local carbonate river rock as aggregate is acceptable pending demonstration that no problems will exist in the resulting concrete. The proposed modification to give the contractor discretion in removal of steel forms is not supported. Instead, several recommendations are made to specifically reduce the number of forms left, thereby reducing potential migration pathways.

EEG's recommendations have been considered in the DOE's decision-making process.

9.4.10.23 EEG-83 (2002): Identification of Issues Relevant to the First Recertification of WIPP by Lawrence E. Allen, Matthew K. Silva, James K. Channell (Allen et al. 2002)

The following is a summary of the EEG report (EEG-83) and therefore represents the views of the EEG and not necessarily those of DOE.

This report updates issues that the EEG considers important for the first recertification of WIPP. These issues encompass a variety of technical areas, including actinide solubility, fluid injection scenarios, solution mining, Culebra flow and transport, spallings modeling, and nonrandom waste emplacement. The report made the following recommendations.

Some uncertainty remains in understanding the persistence of higher Pu oxidation states because of reliance on modeling (with its associated assumptions) and limited experimental results. The EEG recommends additional experimental work towards parameters for a proposed conceptual kinetic model of Pu solubility. In addition, the EEG recommends an intrusion scenario in PA that would account for a heterogeneous, noninundated repository that may include persisting higher oxidation states of Pu.

Intrusion scenarios including the consequences of fluid injection were rejected at the time of the CCA. With increasing drilling activity in the vicinity of the WIPP, fluid injection scenarios should be reexamined for recertification PA. These scenarios should consider potential consequences from oil field secondary recovery techniques, such as waterflooding, in addition to ancillary injection operations, such as brine disposal and pressure maintenance wells. The WIPP resides in a resource rich locale, and PA should consider all reasonable activities associated with such a location.

Likewise, solution mining scenarios should also be reconsidered during recertification. Solution mining should be anticipated for extraction of potash reserves as well as for the excavation of salt caverns for storage of natural gas, oil field wastes, and chemical feedstocks. Consideration of solution mining for potash extraction is a natural alternative for a maturing mineral district as ore grades decrease below the economic cutoff necessary for traditional mining methods. Dissolution of halite to create underground storage caverns is a practice already used in the Delaware Basin for oil field waste and natural gas. Research suggests that it may also be a viable method for storage of other items, such as chemical feedstocks.

The Culebra dolomite unit of the Rustler Formation is acknowledged as a likely pathway for breach of the WIPP repository. Hence, long-term PA requires an accurate understanding and modeling of flow and potential actinide transport.

Most of the issues concerning the Culebra raised at the time of the CCA resulted from poor discretization of the modeling grid and the inherent heterogeneity of the aquifer. The DOE had originally planned to replace the previous flow code with MODFLOW and implement a finer grid. This, coupled with a new transport code, STAMMT-L, would have addressed problems with numerical dispersion and spatial truncation errors. In addition, STAMMT-L incorporates a dual-porosity, multirate approach, which the DOE demonstrated to be a superior representation of transport within the heterogeneous character of the Culebra.

The EEG remains concerned over the continuing water level increases in the Culebra aquifer. The DOE is currently engaged in an effort to determine the source, or sources, of the rising water elevations, which have continued to increase for the last 14 years. Until a cause is determined, the validity of the Culebra conceptual for PA is in question. The EEG recommends that the DOE reconsider its decision not to change the Culebra modeling codes and grid discretization. In addition, the EEG urges the DOE to conclusively determine the source of the water level increases and adjust the conceptual model accordingly.

The CCA demonstrated the importance of spallings as a potential release mechanism. The spallings model used in the CCA did not adequately characterize the physical processes of spall. Work was in progress by the DOE on a new spallings model intended for use during recertification. This model was to improve predictions of long-term performance, reduce uncertainty, and enhance public confidence. However, the DOE recently announced that the new model would only be used for impact analysis and not for recertification PA. The EEG urges the DOE to reconsider and to use the new model for PA.

Random emplacement of waste in the repository was assumed in the CCA. However, waste emplacement practice since the 1999 opening has demonstrated that random emplacement is not likely. Specific waste-streams shipments to WIPP depend on the DOE’s agreements with the host states, and on the readiness of particular waste streams for shipment. It has been previously demonstrated by the DOE that nonrandom emplacement could increase the mean release values. The EEG recommends that DOE develop a waste-loading plan based on their shipment schedule. All intrusion scenarios could then consider nonrandom emplacement, providing better estimates of releases.

The DOE has considered all these recommendations in the preparation of CRA-2004.

9.4.10.24 EEG-85 (2003): Analysis of Emplaced Waste Data and Implications of Non-Random Emplacement for Performance Assessment for the WIPP by Lawrence E. Allen and James K. Channell (Allen and Channell 2003)

The following is a summary of the EEG report (EEG-85) and therefore represents the views of the EEG and not necessarily those of DOE.

The WIPP Land Withdrawal Act (LWA) recognized that after the initial certification of the WIPP and start of disposal operations, operating experience and ongoing research would result in new technical and scientific information. The EEG has previously reported on issues that it considers important as the DOE works towards the first recertification. One of these issues involves the assumption of random emplacement of waste used in the PA calculations in support of the initial certification application. As actual waste emplacement data are now available from four years of disposal, the EEG performed an analysis to evaluate the validity of that initial assumption and determine implications for PA.

Panel 1 was closed in March 2003. The degree of deviation between actual emplaced waste in Panel 1 and an assumption of random emplacement is apparent with concentrations of ^{239}Pu being 3.20 times, ^{240}Pu being 2.67 times, and ^{241}Am (americium) being 4.13 times the projected repository average for the space occupied by the waste.

A spatial statistical analysis was performed using available Panel 1 data retrieved from the WWIS and assigned room coordinates by SNL. A comparison was made between the waste as emplaced and a randomization of the same waste. Conversely, the distribution of waste as emplaced is similar to the distribution of waste in the individual containers and can be characterized as bimodal and skewed with a long high-concentration tail. The distribution of randomized waste is fairly symmetrical, as would be expected from classical statistical theory. In the event of a future drilling intrusion, comparison of these two distributions shows a higher probability of intersecting a high-concentration stack of the actual emplaced waste over that of the same waste emplaced in a randomized manner, as was assumed in the certified PA calculations. This suggests that the methodology used during the certification PA calculations underestimated potential releases by cuttings and cavings. That methodology sampled each layer in a stack separately and used the mean concentration for each waste stream.

The DOE performed a spallings release bounding analysis at the time of the initial certification. However, the selection of the statistical sample size of the bounding analysis assumed independence of samples, which is not characteristic of nonrandom waste emplacement. Instead, it is demonstrated that the emplaced waste is spatially dependent. Therefore, the bounding analysis may not be adequate in the event of continued nonrandom emplacement. As for cuttings and cavings releases, the probability of a high-concentration intersection during an intrusion is increased because of nonrandom emplacement. PA calculations should either incorporate this increased probability or an adequate bounding calculation should be performed using spatial statistical methodology.

The use of Pipe Overpack Containers for isolation of the high ^{239}Pu waste may reduce the amount of material brought to the surface as a result of an intrusion. However, the integrity of these containers over the regulatory period has not yet been demonstrated. If the DOE wishes to take credit for the container, the DOE needs to provide an analysis of structural integrity and the potential effects resulting from the use of Pipe Overpack Containers.

The DOE has addressed the issues raised in this report in the preparation of CRA-2004.

9.4.10.25 EEG-86 (2003): Contact Handled Transuranic Waste Characterization Requirements at the Waste Isolation Pilot Plant by Matthew K. Silva, James C. Channell, Ben A. Walker, and George Anastas (Silva et al. 2003)

The following is a summary of the EEG report (EEG-86) and therefore represents the views of the EEG and not necessarily those of DOE.

The EEG has been evaluating the development of WAC since 1979. This report consolidates the findings and recommendations of the EEG's technical reviews and current positions with respect to waste characterization requirements. Through this report, the EEG has offered the following observations and recommendations for waste characterization requirements

9.4.10.25.1 Acceptable Knowledge

AK is the principle waste characterization technique for all of the regulatory agencies. AK is necessary and should be retained. At this time, EEG supports the use of the Hazardous Waste Facility Permit (HWFP) AK requirements, since they are the most explicit.

9.4.10.25.2 Headspace Gas Sampling and Analysis

It is desirable to maintain a comprehensive Headspace Gas (HSG) program for WIPP CH-TRU waste. However, it should be possible to require less than 100 percent headspace gas sampling in some cases. The primary concern is with organic sludges and older waste containers where knowledge of the waste is of lesser quality.

9.4.10.25.3 Drum Age Criteria

Drum Age Criteria (DAC) is necessary to ensure that HSG sampling of waste containers will measure gas concentrations at least 90 percent of equilibrium. DAC values are required in both the HWFP and the TRAMPAC. The EEG supports this requirement.

9.4.10.25.4 Real Time Radiography

All WIPP waste containers are required to undergo either radiography or visual examination (VE) by the HWFP. Usually retrieved wastes undergo Real Time Radiography (RTR) and newly generated wastes are examined by VE. RTR has been a very effective means of verifying AK and discovering prohibited items in waste containers. It is also used to show compliance with several EPA and TRAMPAC requirements. The overall radiography program is an important part of the WIPP waste characterization program and should be retained. It may be possible to reduce some of the detailed procedural requirements in the HWFP.

9.4.10.25.5 Visual Examination for Retrievably Stored Waste

A small percentage (currently less than two percent) of retrievably stored waste is required by the HWFP to undergo VE for confirmation of RTR. The VE process has the potential for slightly greater radiation exposure than the other waste characterization requirements, although the EEG has seen no data to indicate that exposures are significant enough to justify reducing the requirement. The DOE has been successful in modifying the HWFP on retrievably stored VE, and this would be the preferred process for seeking further reductions.

9.4.10.25.6 Visual Examination for Newly Generated Waste

VE is the method DOE usually prefers for newly generated waste because it can be done at the time the waste container is filled. The EEG has not objected to any part of this requirement except to state that the requirement for two trained VE operators to perform the visual process "may be overkill" and that a single verification should be adequate.

9.4.10.25.7 Coring Sampling and Analysis

Currently the EEG continues to believe that the homogeneous sampling and analysis are unnecessary characterization requirements in the HWFP. EEG's principal reason for this position is that the data are not used for any additional regulatory control (metals releases from accidents or long-term processes would be controlled by radionuclide control requirements and VOCs and semi-volatile organic compound (SVOC) by HSG or the Confirmatory VOC Monitoring Plan).

9.4.10.25.8 Level II Management and Waste Certification HWFP Requirements

The DOE has listed these management and certification requirements as characterization activities in a recent cost analysis. EEG has not previously commented on these requirements. However, EEG indicated that their current evaluation stated that the required procedures are very detailed and somewhat redundant. This may be one of the areas to which the general EEG comment, "We believe waste characterization requirements are excessive," applies.

9.4.10.25.9 Characterization Support HWFP Requirements

EEG remains supportive of the WIPP audit and surveillance program. EEG has also stated that it does not believe the relaxation of audit requirements and QA/QC is an appropriate way to reduce the regulatory burden.

9.4.10.25.10 EPA Non-Radiological Requirements

EPA's residual liquids, nonferrous metal, and CPR materials requirements should remain and can continue to be determined as they are now, by the RTR and VE requirements of the HWFP.

The ferrous metal requirement can continue to be met by counting waste containers emplaced in the repository.

9.4.10.25.11 EPA Radiological Requirements

The EEG agrees with the radioassay requirements for CH-TRU waste specified in Appendix A of the report and the current procedures for modifying the document.

Current requirements for reporting the 10 required radionuclides should remain. ^{241}Pu should also be reported. The current requirement that all radioassay should be performed by WIPP-certified assay systems should be maintained. Justification for less than 100 percent quantification and determination of isotopic ratios may be possible for some, but certainly not all, waste streams.

9.4.10.25.12 NRC Container Properties

The TRAMPAC requirements for residual liquids, filter vents, and the sealed container prohibition should be retained. These are all verified by requirements in the current HWFP.

9.4.10.25.13 NRC Nuclear Properties

All nuclear property requirements should be retained and Appendix A of the CH-TRU WAC methodology should be used.

9.4.10.25.14 NRC Gas Generation Requirements

Requirements for measuring the chemical, payload classification, and radionuclide concentrations necessary to ensure H gas concentration criteria are met must be retained. There have been many changes, via the Certificate of Compliance (C of C) revision process, which have allowed additional containers to be shipped without changing the H gas criteria and additional changes may be justifiable in the future.

The flammable gas concentration limit of ≤ 500 ppm should be retained as described in the current revision of the TRAMPAC. Alternate methods (with appropriate QA) will be necessary if future changes to the HWFP affects the use of HSG sampling as the method for meeting this criteria.

9.4.10.25.15 Waste Isolation Pilot Plant Waste Acceptance Criteria

The WAC has served a useful historic purpose in developing initial criteria that have been adopted by the other three regulatory agencies. Currently it is a useful document for listing most of the requirements from all four sets of criteria. It would be more useful if the technical justification for each criteria or requirement were restored.

The unique role of the WAC in including any necessary operational safety and health requirements not included elsewhere is very important and must be constantly evaluated via the technical safety requirements (TSR) portion of the CH-TRU Safety Analysis Report, and any necessary changes incorporated into the CH-TRU WAC.

This report was published in late September 2003, during the final preparation phase of CRA-2004. It has been included here for completeness. The DOE will consider these recommendations in dealing with the waste characterization issues in the future.

9.4.11 Fracture Expert Group Review

SNL convened the Fracture Expert Group (FxG) during the spring of 1993. A summary report of the FxG meeting (see CCA Appendix PEER) was prepared in March 1993.

As discussed in the meeting report, the charter of the group was to:

1. Review the current (as of 1993) BRAGFLO model assumptions for permeability and porosity as a function of pressure for their adequacy as first-order representations of the changes in the anhydrite beds adjacent to the waste disposal horizons due to pressurization of the formation.

2. Recommend improvements in the characterization of changes in permeability and porosity in the anhydrite beds adjacent to the waste disposal horizons due to pressurization of the formation.

An evaluation of the FxG review against the screening criteria is provided in Table 9-16. Since the 19-member FxG contained SNL staff, SNL contractors, and external experts, it was not a truly independent review group. However, the group, and especially the 11 external experts, provided a valuable review of the issues and made several valuable recommendations which were, to a large extent, independent. The group included nationally and internationally recognized expertise in experimental mechanics, materials science, fracture and fluid mechanics, and computational fluid dynamics. The group members were as follows:

- Pierre Bérest, Ecole Polytechnique, Palaiseau, France;
- Barry Butcher, SNL;
- Peter Davies, SNL;

Table 9-16. Fracture Expert Group

1. Is the peer review relevant to the CCA?	Partially – although the FxG reviewed the BRAGFLO conceptual model, its focus was primarily related to compliance with Part 268, rather than Part 191, requirements.
2. Was there a formal report prepared by the reviewer?	Yes – meeting summaries were prepared.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the FxG reviewed the adequacy of 1993 BRAGFLO model assumptions as they relate to repository pressurization.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Partially – the FxG's purpose was as much to recommend improvements in BRAGFLO as to evaluate its adequacy.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – group members are recognized experts in their respective fields.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Partially – the 19-member FxG contained SNL staff, SNL contractors, and external experts so it was not a truly independent review group. However, the 11 external experts provided valuable review and recommendations from an independent and impartial perspective.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Yes – the FxG provided valuable review of one of the conceptual models used in PA.

- Chandrakant Desai, University of Arizona;
- Dick Ewing, Texas A&M University;
- Mert Fewell, SNL;
- Mel Friedman, Texas A&M University;
- Bezalel Haimson, University of Wisconsin;
- Samuel W. Key, RE/SPEC Inc.;

- Jane Long, Lawrence Berkeley Laboratory;
- Darrell Munson, SNL;
- Sia Nemat-Nasser, University of California-San Diego;
- Karsten Pruess, Lawrence Berkeley Laboratory;
- Thomas Russel, University of Colorado at Denver;
- Chin-Fu Tsang, Lawrence Berkeley Laboratory;
- Palmer Vaughn, Applied Physics Inc.;
- Wolfgang Wawersik, SNL;
- Stephen Webb, SNL; and
- Teng-Fong Wong, State University of New York-Stonybrook.

The meeting summary report concluded that "The proposed first-order model in BRAGFLO for representing changes in permeability and porosity due to pressure-induced changes in the anhydrite is an acceptable first approximation." The FxG report also made recommendations for additional studies to support an extended and improved second-order model in BRAGFLO for simulating the two-phase flow occurring in the altered anhydrite marker beds (MB 138 and MB 139). These recommendations are summarized in the FxG report (CCA Appendix PEER).

Recommendations by the FxG for additional studies of fracturing were driven by concerns regarding the gas-phase transport of VOCs away from the repository via pressure-induced fractures. Gas-phase transport is not a mechanism that could contribute to actinide releases from the disposal system. The DOE therefore concludes that the current PA model used to approximate the effects of pressure-induced fracturing, which is a refinement of the model presented to the FxG, is adequate for estimating actinide releases from liquid-phase transport. The FxG meeting summaries were provided to the recent conceptual models peer review panel for consideration during its evaluation of the WIPP conceptual models.

9.4.12 Fanghänel Review – WIPP Thermodynamic Model for Trivalent Actinides

Dr. Thomas Fanghänel of the Institut für Nukleare Entsorgungstechnik, Forschungszentrum Karlsruhe, Germany, was contracted to perform an independent review of the thermodynamic models WIPP developed to predict potential dissolved concentrations of actinides in WIPP brines. An evaluation of his review against the screening criteria is provided in Table 9-17.

He was tasked to provide an independent assessment of the methods used to estimate the dissolved concentrations of III, IV, and VI actinides. For the V actinides, he performed an independent assessment of the WIPP augmentation of his neptunium (Np)(V) thermodynamic

Table 9-17. Fanghänel Review of the WIPP Thermodynamic Model for Trivalent Actinides

1. Is the peer review relevant to the CCA?	Yes – the reviewer evaluated one of the models used in the WIPP PA.
2. Was there a formal report prepared by the reviewer?	Yes – a report was prepared.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the work was a review of the WIPP thermodynamic model for predicting dissolved concentrations of trivalent actinides in WIPP brines.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the review evaluated the adequacy of the WIPP thermodynamic model for trivalent actinides.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – Dr. Fanghänel is an internationally recognized expert.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the reviewer is independent of the WIPP project.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

model, as well as its use for estimating dissolved concentrations of V actinides in WIPP brines. He performed the review and submitted his final report, dated May 7, 1996. A copy of the full report is provided in CCA Appendix PEER.

Dr. Fanghänel is an internationally recognized expert regarding the thermodynamic modeling of actinides and is completely independent of the WIPP project. His qualifications include extensive experience with the development and evaluation of thermodynamic models for actinides. He is first author of a journal publication documenting the Np(V) dissolved concentration model that serves as the basis for the WIPP +V actinide dissolved concentration model.

The following paragraphs are quoted from Dr. Fanghänel's report:

> For the WIPP thermodynamic model the ion interaction approach (Pitzer equations) was chosen for modeling the excess properties of the aqueous solution (activity coefficient model). At present, the Pitzer approach is the most sophisticated semiempirical approach for the Gibbs excess energy of a concentrated electrolyte solution. It is widely used and a database with ion interaction parameters covering a large variety of different solution species is available.....
>
> The WIPP model treats the interaction of AN(III) with Cl^- and SO_4^- as strong ion-ion interaction without invoking the formation of complex species. Within the composition range of the WIPP brines, this is a reasonable approach, which was demonstrated in several comparisons between model calculations and data...
>
> The applied assumptions for the development of the WIPP thermodynamic model are conservative and simplify the overall model. This is a prerequisite for calculating dissolved actinide concentrations in the very complex repository system.
>
> In general, the model represents the present state of the knowledge of aqueous solution thermodynamics. The chosen activity coefficient model and the applied data base are, with a few exceptions, suitable for calculating maximum trivalent actinide concentrations in WIPP brines.
>
> The model needs to be improved in some parts. This concerns in particular the hydrolysis equilibria of trivalent actinides which have to be introduced into the model. Moreover, the reviewer recommends that the model regarding the interaction of carbonate complexes in concentrated electrolyte solutions be refined.

In accordance with Dr. Fanghänel’s suggested improvement in the model concerning the hydrolysis equilibria of trivalent actinides, the recommended data were incorporated into the CHEMDAT database. Regarding the second suggestion, carbonates are no longer considered to be significant to repository performance due to the implementation of MgO backfill.

9.4.13 Independent Technical Review of the Bin and Alcove Test Programs

The objective of this ITR team assessment of proposed TRU waste experiments at WIPP, as specified in the charter, was to: “Review the need for, and technical validity of, the Bin and Alcove test programs, as defined in the Test Phase Plan, the Technical Needs Assessment Document, and individual test plans.”

The team consisted of nine technical personnel from the DOE, LANL, Lawrence Livermore National Laboratory (LLNL), and private consultants. The team members had a large amount of expertise and experience in mechanical, chemical and civil engineering, earth and environmental science, and geology. The team was composed of the following members:

- Stephan Brocoum (Team Leader), DOE, Office of Geologic Disposal;
- Philip Thullen (ITR Team Leader), LANL;
- Deborah Bennett (ITR Team Leader), LANL;
- Richard Beddoes, Golder Associates;
- Corale Brierley, Private Consultant;
- Jan Docka, Roy F. Weston, Inc.;

- Joseph Farmer, LLNL;
- Ron Guimond, Ogden Environmental and Energy Services;
- Stan Kosiewicz, LANL;
- Abraham Lerman, Northwestern University;
- John Shaler, Private Consultant;
- Terry Steinborn, Applied Research Associates, Inc.; and
- Dave Swale, British Nuclear Fuels Limited.

Although the independence of the ITR could be questioned because it had a DOE staff member as Team Leader, Dr. Brocoum, as a Director in the Office of Geologic Disposal, had no responsibility or authority as regards the WIPP project. Further assurance of the independence of the team was provided by the credentials and professional stature of the team members and the direct oversight of the ITR review by the Technical Oversight Board (TOB). The independence and technical qualifications of the ITR members were verified by several parties prior to commencement of work. A summary evaluation of the ITR team against the screening criteria for peer reviews is shown in Table 9-18.

The team began its review in July 1993, and completed a final report (see CCA Appendix PEER) in December of that year. The review process consisted of document review, formal presentations by the DOE and its contractors and other groups, and interviews with personnel. The team met several times to develop consensus on issues and recommendations and to prepare its report.

A TOB was chartered to review all aspects of the ITR team's activities. The TOB was composed of senior level individuals with extensive experience in the development, execution, management, and evaluation of large and technically involved projects. The TOB members included

- Dr. Colin Heath (Chairman), GC Management Associates;
- Mr. Richard Baxter, Independent Consultant;
- Mr. William Hamilton, Independent Consultant;
- Dr. Mujid Kazimi, Massachusetts Institute of Technology;
- Mr. Dennis Lachel, Lachel and Associates, Inc.;
- Mr. John Maddox, Independent Consultant; and
- Ms. Debra Marsh, Marsh Consulting Group, Ltd.

Table 9-18. Independent Technical Review of the Bin and Alcove Test Programs at the WIPP

1. Is the peer review relevant to the CCA?	Yes – this review addresses waste characterization and gas generation issues.
2. Was there a formal report prepared by the reviewer?	Yes – there was a formal report.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – this review addressed the adequacy of plans for testing to be done for waste characterization and PA.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – this review addressed the adequacy of the work and made recommendations for changes.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the team members are recognized as experts in their respective disciplines.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – although the Team Leader was a DOE staff member, he had no organizational responsibility for the WIPP project. Also, the professional stature of the ITR members and the oversight of the TOB ensured the independence of the ITR team review.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

They provided a solid reference point of experience and ideas against which the ITR team tested its ideas regarding lines of inquiry and the logic and validity of findings and conclusions. The results of the review were discussed with the TOB, and their guidance was used in preparation of the ITR report.

The following statements are excerpted from the "Executive Summary" of the ITR report.

> Principal Assessment
>
> The review team concluded that: there is no scientific, regulatory, or operational imperative to perform the Bin or Alcove tests at WIPP with radioactive waste. Other tests can and should be performed at WIPP and elsewhere to confirm information used for regulatory compliance

> demonstration and certification. This is an assessment of the technical justification for the tests, not of the ability of site personnel to perform the tests or of the repository to accept TRU waste.
>
> Path Forward Recommendation
>
> Preparation and submission of compliance and permitting packages at the earliest possible date are the foundation of the recommended path forward. All other near term work elements should support these activities. All regulatory permits, approvals, and certification should be acquired before any in situ confirmatory or operational tests are performed in WIPP with radioactive waste.
>
> A lack of clear guidance from cognizant regulators on specific requirements for regulatory compliance should be the only source of future delay in operating WIPP as a TRU waste repository. While most, although not all, of the relevant regulations exist, no clear statement of what constitutes acceptable submissions has been produced by the regulatory bodies....The ITR team believes that delay will be minimized by making the regulators part of the process through early submission of the regulatory packages.
>
> Although all regulations do not exist and existing regulations may change, the ITR team believes that sufficient gas generation information is available to complete the performance assessments and other elements required to prepare and submit compliance and permitting packages within 18 months. The recommended conceptual compliance and permitting process will allow the TRU waste disposal phase to begin in three years if specified milestones are met...
>
> Bench-scale laboratory tests using simulated and/or actual waste should be continued or completed, and additional tests initiated if required. Results of bench-scale tests will not only explain individual gas generation mechanisms but also the synergistic effects of combined mechanisms....
>
> ..... These tests can be performed above ground, at WIPP or elsewhere, unencumbered by mine safety regulations.

As recommended by the ITR team, the bin and alcove tests were subsequently abandoned and the WIPP program was redirected to completing the regulatory compliance documentation on an accelerated schedule. Bench-scale laboratory tests using actual TRU wastes were conducted at LANL and the INEL.

9.4.14 Performance Assessment Reviews

In 1989, SNL prepared a PA methodology report (Marietta et al. 1989) which provided information on the PA process developed to demonstrate compliance with criteria under development for 40 CFR Part 191, Subpart B. Formal comments on the methodology report were provided to the DOE by the EPA and the NMED. The DOE responses to the comments were subsequently provided in the 1990 PA report.

The DOE, through SNL, published iterative PA reports describing the WIPP disposal system beginning with the first PA report in 1990 (Bertram-Howery et al. 1990), followed by subsequent iterations in 1991 and 1992. Each updated report constituted a substantial revision of the previous document based on new information, experiments, and comments from interested individuals. With regard to comments from interested parties, a number of these reviews could be classified as peer reviews for the purposes of this application. An evaluation of these reviews against the screening criteria for peer reviews is provided in Table 9-19.

Table 9-19. External Review of the WIPP PA Reports

1. Is the peer review relevant to the CCA?	Yes – the reviews specifically focused on the PA reports.
2. Was there a formal report prepared by the reviewer?	Yes – the reviews evaluated the adequacy of the WIPP PA reports.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the reviews addressed the adequacy of the PA reports.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the reviews were based on evaluations of the PA.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the reviewing organizations are recognized as experts in their respective disciplines.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Yes – the reviewers were independent of the WIPP project.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	N/A

9.4.14.1 1990 Performance Assessment Report

The first PA report (Bertram-Howery et al. 1990) was issued in December 1990. As noted above, the 1990 report provided responses to the EPA and NMED comments that had been received on the 1989 methodology document.

Several groups reviewed and commented on the 1990 report. In particular, several requests were made from the NMED and others for additional clarification of several aspects of the report. Specific responses to the comments provided by the various reviews were developed and subsequently documented in the 1991 PA report.

9.4.14.2 1991 Performance Assessment Report

The second PA report (WIPP Performance Assessment Division 1991) was issued in December 1991. The 1991 report included responses to comments that had been received from the reviews of the 1990 report.

Intera, Inc. was requested by the SNL WIPP Performance Assessment Division to review Volumes 1-4 of the 1991 WIPP PA report (WIPP Performance Assessment Division 1991).

Although the independence of the review could be questioned because it was contracted directly by the WIPP PA Division, it is provided here for completeness; the results of the review were important in establishing the direction of PA. The review's purpose, as stated in the Intera report (see Appendix PEER-2004), was to consider "technical questions pertaining to the performance assessment methodology and its application and results, as well as issues of organization, presentation and flow of information between the various sections, chapters and volumes."

The review is contained in a March 1992 report (see CCA Appendix PEER). The report summary states the following:

> Our major technical concerns are in the general area of treatment of uncertainty in the assessment, including in particular treatment of scenario uncertainty, data and parameter uncertainty, and model uncertainty....
>
> We have also suggested a possible modification to the methodology for generating CCDFs for human intrusion events, and have noted that the treatment of human intrusion, as a particular class of scenarios, is imbalanced in places...
>
> With regard to presentation and organization of the report, there is substantial room for improvement.... In particular, the report is excessively long, and very much in need of a good summary of the order of 100 pages (or less). More attention needs to be paid to the relevance of the information presented to the final assessment results, and to the potential audience for the report. Excessive use of mathematics is made throughout the report, and figures are too few in number, are poorly explained or are too complex. In addition, relatively minor errors are rife, particularly in Volume 3.

The Intera comments were carefully considered by SNL while preparing the succeeding report. Accordingly, appropriate modifications were incorporated in the 1992 PA report. Specific responses to the various third-party reviews were documented in the 1992 PA report.

9.4.14.3 1992 Performance Assessment Report

The third PA report (WIPP Performance Assessment Department 1992) was published in December of 1992. This report provided responses to comments that had been received on the 1991 PA report. As with the earlier PA reports, several groups reviewed and provided comments on the 1992 report. In particular, EPA, NMED, EEG, and the Attorney General (AG) provided comments to DOE. Comments received from the EPA, NMED, and the AG are discussed below. Comments from the EEG are discussed in Section 9.4.10.13.

9.4.14.3.1 Environmental Protection Agency Review of the 1992 Performance Assessment Report

The EPA's review of the 1992 iteration of PA was provided in two separate transmittals. The first group of review comments addressed only Volumes 1 through 3. The second set of comments primarily addressed Volumes 4 and 5.

Review of Volumes 1 through 3

In January 1994, the EPA provided extensive comments on Volumes 1 through 3 of the 1992 iteration of the PA. The EPA grouped its discussion of the issues into six primary categories: (1) format and content, (2) access to information, (3) regulatory issues, (4) use of expert panel elicitation and investigator judgement, (5) models, and (6) QA. The EPA comments and the DOE responses for each comment are provided in Appendix PEER-2004.

Volumes 4 and 5

In October of 1994, the EPA provided final comments to the DOE on the 1992 iteration of PA. Although the comments addressed the entire PA, the primary focus was Volumes 4 and 5. The EPA grouped its comments into five primary categories: (1) scenarios, (2) BRAGFLO and SANCHO computer code relationships, (3) Culebra groundwater modeling, (4) inventory, and (5) institutional controls. The EPA comments and the DOE responses for each comment are provided in Appendix PEER-2004.

9.4.14.3.2 New Mexico Attorney General Review of the 1992 Performance Assessment Report

The New Mexico AG also provided comments on the 1992 PA report. These comments are provided in CCA Appendix PEER, along with the DOE responses.

As part of his review, the Attorney General contracted with Dr. Elisabeth Paté-Cornell. Dr. Paté-Cornell is a Professor of Industrial Engineering and Engineering Management at Stanford University and is currently president of the Society for Risk Analysis. She has written and lectured extensively on probabilistic risk assessment and has testified in Congress on proposed legislation on the subject. Dr. Paté-Cornell prepared a report for the AG entitled Conservatism of the Performance Assessment and Decision Criteria for WIPP. The comments are provided in CCA Appendix PEER with a cover letter documenting its transmittal from the AG to DOE.

9.4.14.3.3 NMED Review of the 1992 Performance Assessment Report

The NMED also provided comments on the 1992 PA report. The comments are provided in Appendix PEER together with DOE responses. The NMED's comments were detailed but focused upon several issues relevant to screening scenarios and events for PA. Within this context, NMED provided detailed comments on three primary issues:

1. additional groundwater migration pathways (the Dewey Lake (Redbeds) Formations and Magenta Member of the Rustler),

2. subsidence potential related to dissolution of evaporite units caused by downward percolation of meteoric or groundwater through inner or outer zones of boreholes, and

3. subsidence potential related to extraction of oil and gas adjacent to the facility boundary.

9.4.14.4 Department of Energy Response to Comments on the 1990, 1991, and 1992 Performance Assessment Reports

In summary, DOE responded to comments from interested groups and individuals by revision of subsequent PA reports and by providing specific responses to those comments in the subsequent reports. Chapter 6.0 is the result of many years of work on PA activities by the DOE. PA has undergone extensive revision as a result of input from groups such as EPA, NMED, EEG, and the AG.

9.4.15 Technical Support Group Reviews

During 1993, the Technical Support Group (TSG) was tasked by the DOE to provide recommendations on the following topics:

- Experimental Plan for Tracer Testing in the Culebra Dolomite,
- PA Parameters, and
- Large-Scale Seals Test Program.

Evaluating the resulting reviews against the screening criteria developed for this application indicated that the first two qualify as peer reviews (see Table 9-20). As regards the large-scale seals test program, the review team was mostly comprised of subcontractors with a long working relationship with the WIPP project. The reviewers' independence could also be questioned for the other two reviews; however, the case for the review's independence was stronger. These reviews are included in this application for the sake of completeness and because they were significant in terms of the PA program. The reports were provided to the appropriate recent peer review panels for consideration. A brief discussion of the selected reviews is presented below.

The members of the review teams included expertise in geochemistry, geomechanics, hydrology, physical chemistry, NEPA compliance, PA, and waste management. The members involved in the reviews included the following:

- Paul Drez (TSG Core Member), Independent Consultant;
- Paul Cloke, Science Applications International Corporation – Nevada;
- David Dennison, Advanced Sciences, Inc. – Denver;

Table 9-20. Technical Support Group Reviews

1. Is the peer review relevant to the CCA?	Yes – the reviews involved aspects of site characterization and PA.
2. Was there a formal report prepared by the reviewer?	Yes – reports were prepared.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the reviews addressed the adequacy of WIPP plans and programs.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the reports addressed the adequacy of work prepared by the WIPP project.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Yes – the reviewers are recognized experts in their respective disciplines.
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Partially – although several of the reviewers were independent, some of the TSG members involved in the reports discussed in this section routinely participated in the WIPP project over a period of several years as subcontractors to DOE.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Yes – the reports were significant in terms of their impact on the WIPP PA program. The reports were also provided to the recent peer review panels.

- Darrel Dunn, Advanced Sciences, Inc. – Denver;
- John Kircher, Battelle;
- David Lechel, Independent Consultant;
- John Schatz, Independent Consultant;
- Jim Tollison, Independent Consultant; and
- Rose Zeiler, Advanced Sciences, Inc. – Denver.

9.4.15.1 Review of Experimental Plan for Tracer Testing in the Culebra Dolomite

The review team was asked to address whether additional experiments for fluid flow and transport characterization of the Culebra are necessary. Additionally, if these experiments were determined to be necessary, the team was asked to evaluate whether the planned Culebra Tracer Tests, as described in the proposed Test Plan, would provide the data necessary to establish whether the Culebra retards radionuclide transport sufficiently to demonstrate that the Culebra is an effective geologic barrier.

The formal report prepared by the team as a result of the review is provided in CCA Appendix PEER, along with the transmittal letter to the DOE.

The recommendations from the TSG report on tracer testing in the Culebra dolomite were considered in the planning of ongoing hydrological studies and testing performed at the WIPP site. In addition, the review resulted in enhanced communication between the principal investigators generating data and the PA staff. The TSG report was provided to the recent conceptual models peer review panel for its consideration.

9.4.15.2 Performance Assessment Parameters

A copy of the report that resulted from the TSG review of the PA parameters is provided in CCA Appendix PEER. The purpose of the TSG review, as stated in the transmittal letter to the DOE, was to

> conduct a detailed review of many of the parameters that form the basis for the PA calculations for the WIPP Project. This effort emphasized the key 49 PA parameters that were sampled in the 1992 PA calculations, and, as time permitted, included a preliminary review of an additional 80 parameters. Data type, data quality, data interpretation, and source documentation were evaluated and each reviewer categorized the data based on their professional judgment. A database called PERFORM was developed to help in the management of the reviews.

From the report's "Summary of Findings," the team concluded that "Results of the TSG review of PA parameters indicate that improvement is needed in areas of Data Quality, Data Interpretation, and Source Documentation. It is the opinion of the TSG that this needs to be accomplished to ensure regulatory compliance."

IRTs were subsequently formed to specifically review and qualify, where appropriate, existing data. As discussed in Chapter 5.0, the IRTs were successful in qualifying a large amount of the data that had been collected prior to establishment of a qualified QA program. Data that were not qualified by the IRTs were qualified by three of the recent peer review panels, as discussed in Sections 9.3.4, 9.3.5, and 9.3.6.

PA parameter values were developed and controlled in accordance with the SNL QAPD and QAPs. QAP 9-2 was developed and used to document the selection, development, and entry of parameter values used in the PA. The PA database is controlled and maintained using SNL QAP 9-4. This QAP establishes the process for ensuring that parameter values and their associated documentation are maintained in a traceable, retrievable, and controlled environment and allow for the reproducibility of results.

Once the requirements controlling the development of parameter values (QAP 9-1 or QAP 9-5) are fulfilled, the parameter/distribution development is documented or referenced on the applicable WIPP Parameter Entry Form (Form 464). Form 464 provides a traceable link to the qualification of those portions of the data packages that support the parameter development.

9.4.16 NEPA Reviews

The NEPA requires formal analysis, documentation, and an appropriate level of review for proposed major federal actions involving potentially significant environmental impacts. NEPA documentation and the associated public review and comment periods provided environmental input and opposing viewpoints from a variety of sources for the DOE decisions regarding development of the WIPP. An evaluation of the external NEPA reviews against the screening criteria is provided in Table 9-21.

NEPA documentation of the WIPP includes the 1980 Final Environmental Impact Statement (FEIS) (DOE 1980) and the 1990 Final Supplement Environmental Impact Statement (FSEIS) (DOE 1990a). Another environmental impact statement, the SEIS-II (DOE 1997), was completed in 1997.

A Draft Environmental Impact Statement (DEIS) (DOE 1979) was prepared by the DOE and provided to the public for review in April 1979. The significance of impacts associated with the various alternatives were assessed. Comments on the DEIS were obtained during seven days of public hearings and a 141-day written-comment period. A total of 167 persons presented oral statements on the WIPP during the public hearings that were held in Santa Fe, Carlsbad, and Hobbs, New Mexico; Idaho Falls, Idaho; and, Odessa, Texas. Ninety-three letters, several longer than 50 pages, were received during the written-comments period. Commenters included: federal agencies such as EPA, NRC, the Department of the Interior, and the Department of Health, Education and Welfare; agencies from at least 26 states, including several New Mexico agencies; and groups like the EEG.

In response to the comments, the DEIS was extensively revised to prepare the FEIS, which was published in October 1980. Comments were grouped into 30 major issues, which were then discussed in Chapter 15 of the FEIS. Appendix P of the FEIS reproduced in full the comments received from various federal agencies and the cover letters from all official responses from the various states. Copies of all comments received, including transcripts of the public hearings, were placed in the DOE public reading rooms for WIPP. The DOE Record of Decision, published January 28, 1981, announced the DOE decision to proceed with the construction of surface and subsurface facilities in southeastern New Mexico.

A draft SEIS (DOE 1989) was published and provided to the public in April 1989. During the 90-day comment period, the DOE held nine public hearings at locations in Colorado, Georgia, Idaho, New Mexico, Oregon, Texas, and Utah. In addition to the testimony of nearly 1,000 individuals who spoke at the hearings, the DOE received 1,275 written documents and two petitions with a combined total of approximately 2,200 signatures.

Table 9-21. NEPA Documentation Reviews

1. Is the peer review relevant to the CCA?	Yes – NEPA documentation addresses long-term performance, siting issues, mitigation, etc. which are directly relevant.
2. Was there a formal report prepared by the reviewer?	Yes – the results of the public reviews were submitted to the DOE. The DOE formally compiled comments and responses.
3. Was the review a peer review rather than a technical review? a. A peer review's purpose is to confirm the adequacy of the work being reviewed. b. A technical review verifies compliance to predetermined requirements; industry standards; or common scientific, engineering, and industry practice.	Yes – the reviews focused on the adequacy of NEPA documentation prepared for the DOE.
4. Was the review a peer review rather than an expert judgment? a. A peer review confirms the adequacy of the work being reviewed. b. An expert judgment is used to elicit either numerical values for parameters (variables) or essentially unknowable information.	Yes – the review evaluated the adequacy of environmental documentation produced for the DOE.
5. Was the technical expertise of the reviewer at least that needed to perform the original work?	Mixed – the technical expertise of the reviewers varied widely, but included several public agencies and oversight groups (e.g., NRC, EEG).
6. Were the reviewers independent? a. Were the reviewers involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed? b. Did the reviewers have sufficient freedom from funding considerations to assure the work was impartially reviewed?	Mostly – very few of the reviewers had any affiliation with the WIPP or DOE.
7. If the answer to any of the above questions is no, is there an overriding consideration which would still serve to qualify the review as an appropriate and acceptable peer review?	Yes – the public comments on the WIPP NEPA documents have, in aggregate, provided an extensive and thorough review of many issues, several of which are relevant to the CCA.

The DOE reviewed the comments, categorized them by issue, revised the draft SEIS as appropriate, and prepared a comment-response document (Volume 3 of the FSEIS) that presents synopses of the comments and the DOE's responses. Indices to the comments were provided in Volumes 4 and 5 of the FSEIS and served to help locate specific questions or statements and the DOE response. Volumes 6 through 13 of the FSEIS reproduce the public comments received on the draft SEIS and transcripts of oral testimony provided during the public hearings. The draft SEIS was extensively revised, as a result of the comments, in development of the FSEIS, which was published in January 1990. The Record of Decision, dated June 22, 1990, documented the DOE determination to proceed with the phased development of the WIPP. The Record of

Decision included a commitment to prepare SEIS-II before deciding whether to proceed with the WIPP disposal phase.

Public scoping activities prior to the publication of SEIS-II included:

- publishing a Notice of Intent in the Federal Register on August 23, 1995 and a notice reopening the comment period, published on October 13, 1995;
- a public comment period from August 23, 1995 to October 16, 1995; and
- public scoping meetings held in Carlsbad, Albuquerque, and Santa Fe, New Mexico; in Boise, Idaho; and two meetings in Denver, Colorado.

The Implementation Plan (DOE 1996d), published in May 1996, documents the results of the scoping process and provides guidance for preparing SEIS-II.

SEIS-II (DOE 1997) was published in September 1997. The purpose of this document was to provide information on environmental impacts of the DOE's TRU waste disposal operations at WIPP. SEIS-II evaluated a Proposed Action, three Action Alternatives based on the waste management options presented in the Final Waste Management Programmatic Environmental Impact Statement, and two No Action Alternatives. The Proposed Action described the treatment and disposal of the basic inventory of TRU waste over a 35-year period. The basic inventory is that waste currently permitted in WIPP based on current laws and agreements. The Action Alternatives propose the treatment of the basic inventory and an additional inventory as well as the transportation of the treated waste to WIPP for disposal over a 150- to 190-year period. The three Action Alternatives included the treatment of TRU waste at consolidation sites to meet WIPP planning-basis WAC, the thermal treatment of TRU waste to meet Land Disposal Restrictions, and the treatment of TRU waste by a shred and grout process. The No Action Alternatives proposed the dismantling and closure of WIPP and storage of the waste. One No Action Alternative proposed treating the waste thermally before placing it in retrievable storage.

SEIS-II evaluated environmental impacts resulting from the various treatment options; the transportation of TRU waste to WIPP using truck, a combination of truck and regular rail service, a combination of truck and dedicated rail service, and the disposal of this waste in the repository. Evaluated impacts included those to the general environment and to human health. Additional issues associated with the implementation of the alternatives were discussed to provide further understanding of the decisions to be reached and to provide the opportunity for public input on improving DOE's Environmental Management Program.

9.4.17 International Peer Review by the Nuclear Energy Authority/ International Atomic Energy Agency International Review Group, 1996-97 (NEA/IAEA 1997)

Agreement was reached on June 7, 1996 between the DOE, the NEA OECD, and the International Atomic Energy Agency (IAEA) to organize an international peer review of the long-term safety analysis of the WIPP. The objective of the joint NEA/IAEA peer review was to examine whether the postclosure assessment of the WIPP described in this application is appropriate, technically sound, and in conformity with international standards and practices.

The peer review was organized jointly by the NEA and the IAEA. The agencies appointed an International Review Group (IRG) of seven international experts actively involved in national radioactive waste management programs - from waste management organizations, national regulatory bodies, universities, and scientific consultancies. Two representatives each from the NEA and the IAEA provided a joint secretariat and contributed technically to the review.

None of the members of the IRG had ever worked directly on the WIPP project (or worked as a contractor or subcontractor to the DOE). All, however, had participated in international meetings, projects, and comparison exercises in which the WIPP project had been represented, and had some prior knowledge of the project and of PA as practiced by the DOE. In some cases, this knowledge was extensive and detailed, and gained over many years in bilateral or multilateral exchanges.

The following members served on the IRG:

- Ken Bragg, AECB, Canada, Chairman;
- Jordi Bruno, QuantiSci, Spain;
- Klaus Kühn, Technical University of Clausthal, Germany;
- Sören Norby, SKI, Sweden;
- Richard Storck, GRS, Germany;
- Trevor Summerling, Safety Assessment Management Ltd., U.K.;
- Hiroyuki Umeki, PNC, Japan;
- Arnold Bonne, IAEA, Secretariat;
- Gordon Linsley, IAEA, Secretariat;
- Phillipe Lalieux, NEA/OECD, Secretariat; and
- Claudio Pescatore, NEA/OECD, Secretariat.

The review began in October 1996 and was conducted over a six-month period. The review was based on detailed documentation provided by the DOE, a site visit to the WIPP, and discussions with the specialists in the WIPP project. A report titled “International Peer Review of the 1996 Performance Assessment of the US Waste Isolation Pilot Plant (WIPP)”containing the group’s findings were published in April 1997. The full report is included in Appendix PEER-2004.

The rest of the text in this section is a summary of the IRG report and therefore represents the views of the IRG and not necessarily those of DOE.

9.4.17.1 Objective of the Review

The terms of reference for the review were negotiated between the DOE, the NEA, and the IAEA based on a first proposal by the DOE. The significant parts of the Terms of Reference are reproduced in Appendix 2 of the URG report (NEA/IAEA 1997). Therein, it is stated that:

> The objective of the international review is to examine whether the post-closure performance assessment of the WIPP in the CCA is appropriate, technically sound and in conformity with international standards and practices.

The interpretation of this objective was discussed at length within the IRG, especially the phrase "in conformity with international standards and practices."

The IRG decided to conduct its examination to answer the following broad questions stemming from the above statement.

1. Is the WIPP 1996 post-closure PA appropriate?

   The IRG agreed that this should be interpreted as meaning appropriate in the context of the objective of the CCA, which is to satisfy the EPA regulations. The IRG also agreed that it should not undertake a formal comparison with the EPA regulations since this is the responsibility of the EPA. In this respect, it is emphasized that this review was organized to provide the DOE an independent, international perspective on the 1996 post-closure PA of the WIPP.

2. Is the WIPP 1996 post-closure PA technically sound?

   The IRG agreed that this item should be the primary focus of the review. For example: Have adequate data and process information been used? Are the conceptual models and their underlying assumptions scientifically based or reasonable? Have adequately tested mathematical and computer tools been applied?

3. Is the WIPP 1996 post-closure PA in conformity with international practices? That is, is the scope of the assessment, methods of analysis, and quality of application consistent with good practice in other countries?

4. Is the WIPP 1996 post-closure PA in conformity with international guidance and standards? That is, are the calculated end-points consistent with international guidance and standards in the manner these are formulated in other countries?

9.4.17.2 Scope

The terms of reference identify the CCA (Volume I) as the primary material to be reviewed. After individual examination of this document and joint discussions, the IRG made the following initial observations and decisions:

- The CCA was prepared by the DOE to comply with the EPA regulations. These regulations provide detailed guidance on how to demonstrate compliance and are focused on the evaluation of specific performance indicators.

- The CCA, Volume I does not constitute a self-contained or sufficient description of the 1996 PA. Rather, it is necessary to examine many of the CCA appendices in order to find technical information at the level required by the IRG.

- The iterative program of PA of the WIPP has been the subject of a number of previous independent reviews, notably by the NAS (1996). These other reviews, several of which are summarized in Chapter 9 of the CCA, Volume I, would not be examined as part of this review.

- Preparing a view on the four broad questions identified in Section 9.4.17.1, the IRG considered that it would also be able to examine and comment on other issues indicated by the terms of reference, such as the clarity and transparency of the documentation.

9.4.17.3 Conclusions

9.4.17.3.1 Observations on the Specificity of the Waste Isolation Pilot Plant Case

- The WIPP project and the CCA are different in several respects from geological disposal projects and assessment documentation in other countries.

- The WIPP facility is sited in an area in which mineral resources are being actively and extensively exploited.

- The regulator has provided detailed guidance on the assessment approach, documentation and, for the assessment of future human actions, model assumptions.

- The CCA is tightly focused on compliance with the EPA regulations, and does not represent a full safety case as understood in most other countries.

These observations are statements of fact, not criticisms. Such differences, however, have had a strong influence on the PA carried out by the DOE, and have been taken into account by the IRG in formulating its conclusions.

9.4.17.3.2 Evaluation with Respect to the Terms of Reference

9.4.17.3.2.1 *Appropriateness*

The CCA was specifically designed by the DOE to meet the requirements of the EPA regulations. The IRG has not found any indication that the information presented is not appropriate in the context of the EPA requirement. This, however, is a matter for the EPA to judge.

9.4.17.3.2.2 *Technical Soundness*

The analyses contained in the CCA are based on an extensive geological data set resulting from high quality acquisition programs and compilation of regional data. This has been supplemented by a focused geotechnical and experimental program that has provided a world-leading understanding of processes relevant to rock-salt behaviour. The uncertainty associated with characterization of the wastes, processes related to waste and backfill evolution in the repository, and chemical speciation of radionuclides in the repository environment are less well understood. In particular:

1. The CCA does not sufficiently explore the possible physical implications of the chemical reactions that the MgO backfill may undergo. These implications may be both favourable and unfavourable to the performance of the facility; and

2. The CCA does not support the assumption, applied in the performance calculations, that the physically and chemically heterogeneous array of waste, packaging, backfill, reaction products, and void space will quickly reach well-mixed homogeneous conditions within the disposal rooms. The basis for this assumption and implications of heterogeneities need to be analysed further.

The CCA indicates good code configuration and management of data flows. The IRG has confidence that the procedures applied in these areas are consistent with best practice for computer simulation internationally. The IRG is also aware of the long involvement of the WIPP project in international comparison exercises, which gives added confidence in the performance of several of the detailed models.

Thus, the IRG has overall confidence in the majority of judgments and assumptions made in developing calculational models of the disposal system and concludes that, in the main, the analyses presented in the CCA are based on appropriate studies and are technically sound.

9.4.17.3.2.3 *Conformity with International Practices*

The methods used to assess the performance of the WIPP facility are generally in conformity with practices used in other countries. These include:

- the selection of FEPs,

- development of scenarios and models representing the evolution of conditions in the repository and the release of radionuclides,

- quantitative analysis of selected scenarios by means of a linked set of models and comparison of the results to regulatory limits.

The probabilistic analysis methods used by the DOE are comparable to those employed in a number of other countries, and the DOE contractors contributed substantially to the development of probabilistic methods in the field of repository postclosure assessment.

Specific aspects of the assessment carried out by the DOE are not in accordance with assessment practices in other countries, and this can be partly traced to the influence of the EPA regulations and the strong focus of the CCA on compliance. For example:

- The probabilistic approach applied by the DOE deals only with parameter-based uncertainty. Conceptual model and scenario uncertainty are not discussed in the CCA. These are considered to be important internationally;

- Results in the CCA focus on the CCDFs of cumulative radionuclide release. Information on the behaviour of intermediate parameters and results of representative deterministic calculations, especially as a function of time, are lacking. Without this, it may not be possible to develop a good understanding of the disposal system's behavior; and

- The EPA has ruled that the DOE only needs to consider a limited set of future human actions and has specified the assumptions to make in assessing these actions. Thus, some scenarios that might affect safety have not been evaluated. The lack of a logically argued explanation for the choice of scenarios analysed, or evaluation of these other scenarios, leads to the impression that the assessment is arbitrary.

9.4.17.3.2.4 *Conformity with International Guidance and Standards*

The CCA focuses on a demonstration of compliance with the EPA containment requirement. The latter is based on collective dose considerations, refers to the total activity in the repository, and cannot be related to the standards based on individual dose and risk adopted in most other countries. Moreover, the EPA regulations do not require the applicant to present descriptions or arguments concerning the performance of the disposal system beyond the 10,000-year regulatory period. Thus, for the general case, the CCA does not present calculated end-points that can be compared with international guidance and standards as implemented in other countries.

The CCA does present dose estimates for the undisturbed performance within the 10,000-year regulatory period based on a conservative hypothetical dose pathway. In this case, the results indicate that the WIPP can easily meet typical performance criteria based on dose to the individual. It is likely that, if undisturbed, the facility could meet individual dose criteria over much longer times, due to the long-term stability of the site and the absence of local, viable fresh water resources.

The IRG asked for information, not included in the CCA, on doses that might be received in the disturbed case from drilling of a borehole into the repository. The results provided by the DOE indicated that, for this scenario, the WIPP facility would meet an individual risk-based standard typical of those used in other countries. The CCA does not demonstrate, however, that no other scenarios could contribute significantly to risk.

9.4.17.3.3 Overall Judgement

The WIPP project and the CCA are markedly different from geological disposal projects and assessment documentation in other countries. In particular, important decisions relating to what is a sufficient method and scope of assessment have already been taken, and the CCA is not required to present a complete PA as understood internationally.

The CCA documentation is not transparent and is difficult to follow even from the point of view of experienced PA practitioners. Technical issues are often difficult to trace and some of the choices made and modeling assumptions are not well supported. This, combined with the specificity of the EPA regulations, made it challenging to distinguish between decisions determined by the regulator and those made by the DOE.

Focusing on the decisions for which the DOE must take technical responsibility, the IRG finds that the PA methodology implemented in the CCA is generally acceptable and conforms to practices in other countries. The IRG also has overall confidence in the majority of judgements and assumptions made in developing calculational models, and believes that the quality of assessment codes and data handling is generally good. Thus, in the main, the analyses contained in the CCA are technically sound.

On specific points, the IRG considers that the DOE should give further attention to:

1. the implications - favourable and unfavourable - that the behaviour of the MgO backfill may have on the performance of the facility, and

2. the basis for assuming that homogeneous conditions will be rapidly reached in the disposal rooms, and the potential consequences of heterogeneities in the source term.

The IRG is of the view that, in the case of undisturbed performance, the WIPP facility would meet radiological performance standards typical of those used in other countries. This judgement is based on the analysis presented in the CCA in respect of the 10,000-year regulatory period and, for times beyond 10,000 years, on the geological stability of the site and the absence of viable fresh water resources. The case of disturbed performance is less clear: supplementary analyses by the DOE indicate that a risk target would be met in respect of an exploratory borehole drilling scenario. The CCA does not (and need not) make the case that this is the most important scenario to consider and, therefore, the IRG cannot reach a definite judgment.

Finally, from the experience of the review, the IRG observes that, by commissioning this international peer review, the DOE has demonstrated a commendable openness and commitment to improving confidence in the PA of the WIPP facility. The DOE and their contractors were very open in their discussions with the IRG, and were able to provide useful responses, often at short notice, on most issues raised. This was very useful and helpful to the review.

9.4.18 GEOTRAP

GEOTRAP is the NEA/OECD Project on Radionuclide Migration in Geologic, Heterogeneous Media. GEOTRAP is devoted to the exchange of information and in-depth discussions on present approaches to acquiring field data and testing and modeling flow and transport of radionuclides in geologic formations for site evaluation and safety assessment of deep repository systems. This information is important for both national waste management programs and the wider scientific community. The WIPP project has actively participated in this project since its inception in 1996.

The project is structured as a series of forum-like workshops at which implementers, regulators, and scientists interact.

The first GEOTRAP workshop, “Field Tracer Experiments: Role in the Prediction of Radionuclide Migration,” was coorganized with the European Commission. It provided an overview of ongoing and planned work in the study of radionuclide transport phenomena and the characterization of relevant geologic media properties.

Variability (heterogeneity) in the properties of the rocks over a wide range of spatial scales is a common feature of most geologic media. Broad agreement exists that its characterization and the corresponding analysis of the consequences for groundwater flow and radionuclide transport form an important part of the safety of deep geologic repositories assessment. The second GEOTRAP workshop, "Modelling the Effects of Spatial Variability on Radionuclide Migration," explored these issues and provided an overview of current developments in the field.

The subject of the third GEOTRAP workshop was "Characterisation of Water-Conducting Features and their Representation in Models of Radionuclide Migration." It investigated how water-conducting features can determine the rate of radionuclide release from the near-field to the far-field, the rate at which radionuclides can migrate with flowing groundwater, and the degree of retention in the geosphere. A key finding of the workshop was that the characterization of the structure and properties of water-conducting features is an important requirement for any PA of deep repository systems.

The fourth GEOTRAP workshop, "Confidence in Models of Radionuclide Transport for Site-specific Performance Assessments," was held in June 1999. The workshop examined the issue of technical confidence building and provided an overview of current developments in this field.

The fifth workshop addressed "Geological Evidence and Theoretical Bases for Radionuclide-Retention Processes in Heterogeneous Media." The Swedish Nuclear Fuel and Waste Management Company (SKB) hosted this workshop in May 2001. The following proceedings of these workshops are available from the OECD Bookshop at www.oecd.org/bookshop.

- <u>Radionuclide Retention in Geologic Media</u>
  Workshop Proceedings, Oskarshamn, Sweden, 7-9 May 2001

- <u>GEOTRAP: Radionuclide Migration in Geologic, Heterogeneous Media</u>
  Summary of Accomplishments (pdf format, 216 kb)

- <u>Confidence in Models of Radionuclide Transport for Site-specific Assessments</u>
  Synthesis and Proceedings of the fourth GEOTRAP Workshop, Carlsbad, New Mexico, United States, 14-17 June 1999

- <u>Water-Conducting Features and their Representation in Models of Radionuclide Migration</u>
  Synthesis and Proceedings from the third GEOTRAP Workshop, Barcelona, Spain, 10-12 June 1998

- <u>Modelling the Effects of Spatial Variability on Radionuclide Migration</u>
  Synthesis and Proceedings from the second GEOTRAP Workshop, Paris, France, 9-11 June 1997

- <u>Field Tracer Experiments: Role in the Prediction of Radionuclide Migration</u>
  Synthesis and Proceedings of an NEA/EC GEOTRAP Workshop, Cologne, Germany, 28-30 August 1996 - Coedition with the European Communities Series Disposal of Radioactive Waste

9.4.19 Institute for Regulatory Science Reviews

RSI is a non-profit scientific and educational organization. It provides independent scientific peer reviews and technical assessments. These reviews and assessments are generally performed in association with professional societies. RSI has performed two peer reviews for the WIPP project. These are briefly described below. Full reports of these reviews are provided in Appendix PEER-2004.

9.4.19.1 Requirements for Disposal of Remote-Handled Transuranic Waste at the Waste Isolation Pilot Plant (2002) (RSI 2002)

This peer review examined methods and techniques DOE proposes to use for characterization of TRU waste and various QA processes. The peer review focused on the DOE's draft Permit Modification Request (Draft Request) to NMED for RH-TRU waste characterization and the corresponding Notification of Proposed Change to EPA.

The RSI review panel (RP) findings are summarized in the following discussion:

Reliance on AK as the analysis tool to meet the waste characterization requirements as listed in the Draft Request can be consistent with the relevant regulations in some instances. In other instances, additional confirmation methodologies in a hierarchy of methods proposed by DOE will be needed to characterize wastes accepted at the WIPP to meet the Data Quality Objectives (DQO). Whether AK alone is sufficient will be dependent upon the nature of the waste and the source and completeness of the data that constitute the AK. The application of the Performance-Based Measurement System approach meets the EPA's guidance on performance-based measurement systems. The Draft Request presents an RH-TRU waste characterization program that is not consistent in all cases with the recommendations of the National Research Council. The Draft Request still includes characterization requirements which the National Research Council criticized as being self-imposed and overly conservative and which have no legal or safety basis.

The Notification of Proposed Change to the EPA 40 CFR Part 194 Certification of the Waste Isolation Pilot Plant describes the nature and scope of the proposed RH-TRU Waste Characterization Program. Consistency with EPA disposal regulations is fully demonstrated and documented in resource documents. The significance of the change is clearly and adequately addressed. The consequences for compliance determinations are clearly stated and technically justified.

The RH-TRU Waste Characterization Program Implementation Plan presented meets the performance factors of the waste characterization program. The waste components have been identified and justified in a general sense, but a detailed description of waste streams from the waste-generating sites is lacking. The programmatic AK steps are somewhat conservative but are sufficient to accomplish the DQOs adopted by DOE- CBFO, and can be reasonably relied upon to meet the DQOs for materials received at WIPP. The distinction between the characterization activities, AK, supplementary, confirmatory, or verification is inadequate in the RH-TRU Waste Characterization Program Implementation Plan, and is made particularly confusing by the definitions.

The Notification of Proposed Change adequately explains and justifies how AK and the WWIS are used to satisfy the quantification and control requirements. The WWIS tracking and control system is currently in use in the CH-TRU waste program, and it is operating satisfactorily. To meet additional tracking and control requirements imposed on RH-TRU waste by the LWA, WWIS will be modified by the addition of data fields.

The RH-TRU Waste Characterization Program Implementation Plan describes a QA program that addresses the appropriate requirements but lacks sufficient detail. Use of the 40 CFR § 194.22 provisions in waste characterization is sufficiently explained. The RH-TRU waste characterization program is reasonably consistent with the report, Improving Operations and Long-Term Safety of the Waste Isolation Pilot Plant (National Research Council/National Academy of Sciences 2001), including its finding of self-imposed requirements that have no legal or safety basis. The Draft Request and RH-TRU Waste Characterization Program Implementation Plan are consistent with the ALARA concept.

Based on a careful assessment of the information presented to the RP and the findings developed in response to the review criteria, the RP provides the following recommendations.

1. A detailed procedure for determining whether there is sufficient AK available on a waste should be developed as part of the permit application.

2. In the final request for RCRA Class 3 Permit Modification, a detailed procedure should be provided to go to other characterization methods if AK is found to be insufficient.

3. DOE should implement the National Research Council recommendation that review of characterization and packaging requirements continue, especially implementation "... over the entire National TRU Program."

4. DOE should provide to the EPA a complete inventory of radionuclides and waste forms so that the EPA may verify the repository performance using its own methods for certification.

5. Appropriate interaction with the EPA and the NMED is recommended.

6. Prior to submission, all permit related documents should be reviewed in detail for completeness, specificity, and clarity by a team experienced in the permitting process.

7. The request for RCRA Class 3 Permit Modification must be expanded to include more specifics and examples for clarity and completeness.

8. The discussion for Table 1 of the draft request for RCRA Class 3 Permit Modification should be expanded to justify why sections of the documents require "no action" or "no changes."

9. Supplemental information should be supplied detailing the waste characterization plans for each waste generating site and DOE's procedures for determining that these plans meet the WIPP WAC.

10. Detailed audit procedures for WIPP and the waste-generating sites should be provided.

11. More detail and specificity on WAC using AK, VE, and radiography should be provided in the permit application.

12. DOE should evaluate the necessity of identifying waste streams by EPA hazardous waste numbers or characteristics.

13. A complete review should be made of what is gained from the remote swiping procedure for “clean” RH-TRU containers and how the information will be used.

The DOE accepted many of the recommendations of the RSI’s review panel in revising the documents reviewed by the panel.

9.4.19.2 Desirability of Performing Certain Transuranic Waste Characterization Tests (RSI 2003)

The following is a summary of the RSI report, “Desirabilty of Performing Certain Transuranic Waste Characterization Tests”:

This report contains the results of an independent peer review performed by the RSI responding to a request from Bob Forrest, Mayor of Carlsbad, New Mexico, to critically review a claim included in a Senate Committee report. The Senate language indicated that the NAS and the EEG had endorsed the elimination of certain tests currently performed to characterize hazardous waste constituents of TRU waste for disposal at the WIPP.

The RP reviewed two relevant reports of the National Research Council (National Research Council 2001, 2002)—the research arm of the NAS, National Academy of Engineering, and the Institute of Medicine. In addition, the RP reviewed a number of documents published by the EEG, an independent group associated with New Mexico Institute of Mining and Technology.

As the principal facility for disposal of the nation’s TRU waste generated as a result of nuclear weapons research, development, and production, WIPP must comply with relevant requirements of the EPA and NMED. Where the EPA regulates certain aspects of the radioactivity content of TRU waste, the NMED regulates the hazardous waste constituents of TRU waste. In addition, WIPP must comply with relevant transportation regulations. Waste must be properly characterized to demonstrate that it meets the requirements for transportation to and disposal at WIPP. Waste characterization activities required at the time of the review included the following, although not all of these techniques were used on each container:

1. Radiography, which is an x-ray technique to determine physical contents of containers;

2. VE of opened containers as an alternative way to determine their physical contents or to verify radiography results;

3. HSG sampling to determine VOC contents of gases in the void volume of the containers;

4. Sampling and analysis of waste forms that are homogeneous and can be representatively sampled to determine concentrations of hazardous waste constituents and toxicity-characteristic contaminants of waste in containers;

5. Compilation of AK documentation into an auditable record, including process knowledge and prior sampling and analysis data; and

6. Non-destructive assay, typically segmented gamma scans and passive/active neutron interrogation, to quantify radionuclides.

Confirmation that the waste complies with the requirement of being not ignitable, corrosive, or reactive is accomplished by AK or appropriate tests.

The U.S. Senate Bill S.1424 states that waste confirmation for all waste received for storage and disposal be limited to:

1. Confirmation that the waste contains no ignitable, corrosive, or reactive waste through the use of either radiography or VE of a statistically representative subpopulation of the waste; and

2. Review of the Waste Stream Profile Form to verify that the waste contains no ignitable, corrosive, or reactive waste and that assigned EPA hazardous waste numbers are allowed for storage and disposal by the WIPP HWFP.

Furthermore, the U.S. Senate Bill S.1424 states that compliance with the disposal room performance standards of the WAP shall be demonstrated exclusively by monitoring airborne VOCs in underground disposal rooms in which waste has been emplaced until panel closure.

The RP was asked to respond to three review criteria identified by the Mayor of Carlsbad, New Mexico. After careful review of documents provided to the RP and appropriate deliberations, the RP provided the following principal conclusions.

1. Based on careful evaluation of the two relevant NRC reports, the RP concludes that the elimination of the waste confirmation requirements mentioned in U.S. Senate Report 108-105 and Bill S.1424 is supported by the NRC.

2. It appears that EEG agrees that the current characterization requirements are excessive. It appears that EEG also agrees that monitoring VOCs in underground disposal rooms is sufficient.

3. Based on the information presented to the RP, the permit modification listed under Section 310 of U.S. Senate Bill 1424 is technically defensible. There is no reason to perform waste confirmation tests that (1) provide insignificant health and safety benefits to the U.S. population, and (2) pose serious radiological and occupational health and safety risks to the workers performing these tests.

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