Attorney General of New Mexico
PO Drawer 1508
Santa Fe, New Mexico 87504-1508

505 827-6000
Fax 505 827-5826

TOM UDALL
Attorney General

MANUEL TIJERINA
MARIAN MATTHEWS
Deputy Attorneys General

April 8, 1994

Mr. George E. Dials
U.S. Department of Energy
Carlsbad Area Office
P.O. Box 3090
Carlsbad, New Mexico 88221

Dear George:

Enclosed are comments prepared by our office concerning the 1992 Performance Assessment.

We look forward to the Department's response to these comments and are prepared to clarify and elaborate on any points.

Best regards,

Lindsay

LINDSAY A. LOVEJOY, JR.
Assistant Attorney General

LAL:mh

cc: Larry Weinstock
Robert Neill
Kathleen Sisneros
Chris Wentz

940401

COMMENTS ON 1992 WIPP PERFORMANCE ASSESSMENT ON BEHALF OF THE ATTORNEY GENERAL OF THE STATE OF NEW MEXICO

The New Mexico Attorney General's office submits the following comments concerning the WIPP 1992 Performance Assessment (SAND 92/0700, the "1992 PA") for the assistance of the DOE, Westinghouse and Sandia National Laboratory in further efforts in this area.

In making these comments this office acknowledges the contribution of other commentators on the 1992 PA, and particularly the Environmental Evaluation Group, which submitted preliminary comments in September 1993 ("EEG 9/93 comments").

Initially, it is unfortunate that the 1992 PA contains no analysis of the performance of the proposed repository based on alternative engineered barriers and waste form modifications. DOE has an obligation to make an informed selection among engineered alternatives, such as cementation, vitrification, shredding, supercompaction, incineration, improved containers, various backfill materials, melting and possible removal of metals, waste loading configurations, disposal room configurations, and the like. An informed selection requires careful study of the benefits of alternative engineered barriers and waste form modifications. An objective release rate standard should be applied to such modifications (see e.g., 10 C.F.R. §60.113), in addition to the CCDF. The precise form of such analysis raises further issues (e.g., what assumptions should be made as to future states and the nature of future human intrusions?) The PA is incomplete without such an analysis.

Further, the PA contains no analysis of the performance of the WIPP site as compared with the performance of a site located outside a resource zone and, thus, not vulnerable to likely human intrusions. DOE should carry out a comparative analysis of one or more hypothetical sites to assess the disadvantages of the resource-rich WIPP site.

The comments which follow concern the contents of the 1992 PA. We have tried to organize these comments by subject area so that related points appear together. Thus, significant issues are interspersed among lesser points. These comments address the following subjects:

1. Scenario selection
2. Human intrusion conceptual models
3. Salado Formation data
4. Waste properties
5. Radionuclide source term
6. Hazardous waste source term
7. Radionuclide inventory
8. Repository-waste interactions
9. BRAGFLO modeling

10. Borehole model
11. Castile brine reservoir
12. Human intrusion probability estimates
13. Repository/shaft design
14. Culebra flow and transport model
15. Cuttings model
16. Compliance demonstration

1. Scenario selection:

This subject is primarily addressed in the 1992 PA in v. 2 ch. 4, which in turn refers to the 1991 PA (1992 PA, v. 2, 4-4; 1991 PA, v. 1, ch. 4). The 1992 PA says that the process of scenario screening will be reexamined when the disposal regulation, 40 CFR 191, is repromulgated. (1992 PA, v. 2, 4-3). The screening process should also be reexamined when EPA issues its compliance criteria, 40 CFR 194. In such reexaminations the following should be considered:

Screening as now practiced employs the criteria of (a) low probability, (b) physical reasonableness, (c) small consequence, and (d) regulatory limitations. (1991 PA, v. 1, 4-12). In general we find that certain scenarios, once selected, have been screened or eliminated on bases that are not adequately explained in quantitative terms. We note in particular:

a. Erosion, sedimentation, flooding, mass wasting, glaciation, and sea level changes causing releases are excluded as not physically reasonable on the premise that climate changes in the next 10,000 years will be within the ranges of conditions occurring within the past 10,000 years (at 4-14, 4-15, 4-18, 4-19). Comments submitted to the EPA by Prof. Roger Y. Anderson (March 16, 1993) point out that the past 10,000 years have been extremely dry in comparison with the average of the past 800,000 years. During at least half of the next 240,000 years climatic conditions are expected to be significantly wetter than at present. Past changes in precipitation and streamflow in the area have involved brief and strong climate episodes departing greatly from average climate. Thus, the assumption of average climate appears to be inappropriate, and these scenarios should therefore be reexamined for inclusion.

b. Pluvial periods are retained for further consideration. (1991 PA, v. 1, 4-15). We note the fact and look to future performance assessments for analysis.

c. Magmatic activity is excluded on the basis of physical unreasonableness, with the explanation that a mid-Tertiary dike system within a zone of crustal weakness was not followed by similar magmatic formations during Pliocene-Pleistocene uplift and fracturing (1991 PA, v. 1, 4-23). The 1991 PA concludes that "a

change in the geologic processes at this location has occurred." Such explanation is entirely too conclusory; a coherent factual hypothesis is required.

d. Deep dissolution is said to be part of the base-case scenario, insofar as it concerns dissolution along the Salado-Rustler contact. (1991 PA, v. 1, 4-27). It is not demonstrated how deep dissolution is incorporated into the modeling of base-case performance.

e. The discussion of human-induced explosions states that seismic effects on the source term or the disposal system are likely to be addressed within parameter uncertainty during modeling. (v. 1, 4-32, 4-32). It should be demonstrated that in fact this will be done.

f. The limitation of the type and amount of human intrusion to be considered is said to be based on the guidance in Appendix B of the 1985 version of 40 CFR 191. That guidance will be superseded by the forthcoming EPA compliance criteria, 40 CFR 194. Thus, the nature of intrusion to be considered must be reconsidered based on forthcoming EPA pronouncements. Further, even following the 1985 guidance, it is not accurate to state that each of the Futures Panel teams estimated future drilling densities substantially lower than 30 boreholes/km^2 in 10,000 years (1991 PA, v. 1, 4-33). The Boston Team, for example, developed a conditional distribution for the average number of boreholes per square mile per 10,000 years, ranging from 12.45 to 199.2 boreholes/mi^2 (SAND 90-3063, at IV-15). In addition, to consider potash and natural gas as the only two resources with economic potential at the WIPP (at 4-33, 4-38) ignores the substantial oil resources in the area (See EEG 9/93 Comments ; Implications of Oil and Gas Leases at the WIPP on Compliance with EPA TRU Waste Disposal Standards, EEG-50 (June 1992), at 13).

g. Human intrusion of various types must plainly be considered in applying the containment requirements. The 1991 PA excludes mining intrusions at the WIPP site based on the 1985 EPA guidance (1991 PA, v. 1, 4-34). We disagree that the EPA guidance excludes this scenario. Again, this exclusion must be reconsidered based upon the compliance criteria. We note that mining beyond the area of the waste panels is retained for scenario development (1991 PA, v. 1, 4-35) and anticipate that future PA's will evaluate such a scenario.

h. Injection wells are also said to be limited in their PA consideration by the 1985 guidance (1991 PA, v. 1, 4-37). This scenario is not excluded even under the 1985 guidance, and Futures Panel teams were unable to estimate its probability (1992 PA, v. 2, 5-7). The scenario must also be reassessed based on the forthcoming compliance criteria. The PA statement that injection wells can be excluded based on lack of consequence (1991 PA, v. 1,

4-37) must be reconsidered in light of the demonstrable widespread effects of well injection in the course of secondary recovery of hydrocarbons typical of the Delaware Basin.

i. The statement is made that withdrawal wells within the repository area are excluded by the 1985 guidance (1991 PA, v. 1, 4-37). It is not at all clear that the drilling and operation of oil or gas withdrawal wells would be deemed a more "severe" intrusion scenario than exploration wells. Further, it is stated that water well emplacement is retained for scenario development (event E3), and we look to future PA's to analyze this scenario. EEG has noted that the TDS concentration in the H-L well referred to hovers close to 10,000 mg./l. EEG Preliminary Comments on 1991 Performance Assessment ("EEG 8/92 comments"), at 24). Moreover, water wells may be drilled in the future for purposes other than obtaining potable water.

j. The grounds for exclusion of a scenario involving irrigation are not convincing (1991 PA, v. 1, 4-40, 4-41). The prospects of irrigation usage are said to be low based upon current land usage in the southeastern United States, current climate conditions, and current water commitments. Before irrigation can be excluded as a relevant scenario, it must be analyzed for probability and consequence based upon changes in such factors.

k. Similarly, the creation of an impoundment at Nash Draw is excluded as improbable, based on present day water supplies and usage (see EEG 8/92 comments, at 24-25). The scenario must be considered based on its probability and consequences, given possible future changes in such factors.

l. Subsidence due to the caving of the waste panels is excluded for lack of consequence (1991 PA, v. 1, 4-49), but this conclusion cannot be justified. First, the degree of subsidence is estimated from admittedly inappropriate analogues and using disposal room models that are obsolete. Second, it is assumed that subsidence occurs uniformly and without bed separations--hardly realistic assumptions. Third, the argument that the subsidence of the Rustler-Salado contact member is an analogous event demonstrating no disruptive consequence ignores the fact that naturally-occurring subsidence is much more gradual than collapse caused by mining. The scenario should be retained.

m. Borehole seal degradation can be considered by sampling a range of input parameters in PA (1991 PA, v. 1, 4-49). Such a method should be adopted. At present assumptions are employed to maximize the flow of brine through the repository and thence to the Culebra, leading to possible underground release. As EEG has pointed out, assumptions as to seal effectiveness are not well-founded factually based on current practices in the basin (EEG 9/93 comments, at 22). PA should evaluate the likelihood and

consequences of releases via improperly sealed boreholes.

n. It has not yet been determined whether to consider a scenario involving nuclear criticality at some location in the transport of plutonium radionuclides. (1991 PA, v. 1, 4-53). EEG has demonstrated that the probability distributions of plutonium distribution coefficients and solubilities are consistent with the possible occurrence of nuclear criticality in the Culebra (EEG 9/93 comments, at 16). We look to future PA's for analyses of such event.

o. Subsidence related to solution mining has not been analyzed, although the 1992 PA recognizes the need (event TS; 1992 PA, v. 2, 4-9). We inquire when this will be done.

p. Possible brine flows to the surface during and in consequence of drilling should be analyzed. Any regulatory limitations on such a scenario must be reassessed after EPA issues its compliance criteria. Current practice is not consistent with an assumption that releases of contaminated brine will be minimal. (EEG 9/93 comments, at 18). Several cases for analysis exist (id. 21) and should be considered.

q. Formation of a brine slurry which is thereafter released in an intrusion event is another scenario which should be analyzed (see EEG 9/93 comments, at 21). Such analysis is obviously bound up with the PA development of the radionuclide source term and the modeling of direct releases (cuttings, cavings, and spallings).

2. Human intrusion conceptual models:

Certain assumptions underlying the existing conceptual models of human intrusion appear to be nonconservative.

a. As stated above, the assumed efficacy of the borehole plug above the repository and above the Culebra may be nonconservative (1992 PA, v. 2, 4-15).

b. Computational approximations do not model E1 explicitly but assume that consequences are the same as E2. (1992 PA, v. 2, 4-18). This assumption should be questioned. The 1992 PA itself says that E1 releases may exceed E2 releases (id.). Whether E2 releases will dominate E1 releases may also change when assumptions as to surface brine releases are altered and when spalling is modeled.

c. As currently modeled, an E1E2 release takes place only when both boreholes occur in the same time interval. (1992 PA, v. 4, 2-16). Indeed, it is assumed that the E1 and E2 intrusions occur simultaneously (1992 PA, v. 4, 2-18). Given the

complexity of the numerous processes involved, it is not now possible to demonstrate that the assumption is conservative. We have been informed that Sandia has made initial experiments involving time-dependent drilling intrusions and inquire as to plans in this regard.

d. The 1992 PA considers only intrusions at the 1,000 year point as to groundwater transport. The statement appears that the Poisson model of intrusions has a rate term of zero after 2000 years (1992 PA, v. 4, 2-18, 2-19). These assumptions, which limit intrusions leading to groundwater releases to a single point at 1000 years, are nonconservative and should be abandoned.

e. In examining direct releases by human intrusion ("cuttings") the 1992 PA assumes that intrusion times are at years 125, 175, 350, 1000, 3000, and 7250 (1992 PA, v. 4, 2-26). The PA should demonstrate that those assumptions are conservative.

3. Salado Formation data:

Sampled parameter values calling for further justification are as follows:

a. Undisturbed halite permeability is sampled over a narrower range in 1992 than in 1991. This parameter is a sensitive one in that it determines how quickly the panel will fill with brine, furnishing a vehicle for radionuclide release. (1992 PA, v. 3, 2-30). The PA department has stated that neither the 1991 nor the 1992 distribution represents the average far-field permeability, the quantity that should be used in the two-phase flow model (Id.). An approach based on experimental data seems necessary. What is planned?

b. Undisturbed anhydrite permeability clearly requires improved data and modeling in forthcoming PA's. At present there is no representation of fracturing under pressure. The 1992 calculations may underestimate lateral gas migration in the anhydrite and overestimate pressurization. (1992 PA, v. 3, 2-57, A-50). When may we expect a model that incorporates pressure-induced fracturing?

c. The 1992 PA reports that work is in progress on modeling the possible pressure dependency of fracture permeability in anhydrite interbeds, and results will be incorporated in future PA's. (1992 PA, v. 2, 2-42). There have been reports concerning such modeling plans at NAS WIPP panel meetings. What is the status of such modeling effort?

d. Anhydrite brine pore pressure in the far-field is another sensitive parameter now estimated by use of regression curves. (1992 PA, v. 3, 2-63). As the PA states, "[w]hether these

results make physical sense remains to be determined." (Id.) What further efforts are planned in this area?

4. Waste properties:

Several issues are unresolved concerning the waste inventory:

a. Concerning inventory data, the Experimental Program Plan, DOE/WIPP 94-008, refers to waste characterization efforts planned or underway at source facilities. (at 3-38, 4-14). DOE has also mentioned plans to develop performance-based waste acceptance criteria. The current PA model, however, employs inventory data based on data submitted by generator sites to the Integrated Data Base. (1992 PA, v. 3, 3-59 et seq., A-137). There is potentially large uncertainty as to volumes of combustibles and metals/glass (1992 PA, v. 3, 3-62). The parameters are significant to RCRA compliance and also, possibly, to radionuclide releases. DOE needs to clarify its plans to establish inventory data for PA.

b. Initial waste saturation is a highly sensitive parameter for RCRA compliance, since it is a principal control on gas generation (1992 PA, v. 3, 3-69). The range of 0, 0.14 based upon investigator judgment calls for substantiation based on characterization efforts. The PA states that the "range of initial brine saturation currently used does not have a sound basis in measured data, and is expected to change." (1992 PA, v. 5, 6-1). What efforts are planned?

5. Radionuclide source term:

The radionuclide source term is highly dependent upon solubility data. We have these questions:

a. "Solubility" (more specifically, mobile actinide concentration) distributions have been constructed on the basis of expert judgment. For future performance assessments DOE proposes to develop a model and lab data with which to determine whether the constructed distributions are supported. Further, lab data will explore different brine compositions, including Salado brines altered by backfill constituents. At this early stage detailed comment is not appropriate. However we note the following:

(a) The methods whereby test data may be deemed to support or "validate" solubility estimates or ranges must be explicitly stated and justified.

(b) The duration of the experiments and the purported attainment of steady-state conditions must be supported

by the proponent of data.

(c) It must be explicit how data from the model will be incorporated into the BRAGFLO model.

6. Hazardous waste source term:

The hazardous waste source term, if modeled at all, is not yet incorporated into assessments of gas and brine migration. Please explain how this is to be done.

7. Radionuclide inventory:

For the 1992 PA the radionuclide inventory is estimated based on input to the 1991 Integrated Data Base (1992 PA, v. 2, 2-50). The CH-TRU inventory is scaled up from the current and projected CH-TRU inventory at five high-volume generating sites. However, uncertainty in the CH-TRU inventory is large, particularly given the potential changes in the sources of CH waste due to changes in weapons production. (1992 PA, v. 2, 2-5). It is possible that DOE may seek to dispose at WIPP of waste from cleanup operations or weapons dismantlement. The RH-TRU inventory in the IDB is approximately the same as the WIPP design capacity and is not scaled up (id.). However, there is also uncertainty as to the characteristics of yet-to-be characterized RH-TRU waste. There is also talk of performance-based waste acceptance criteria. In these circumstances, we point out the following:

a. DOE must explore the ranges of uncertainty of radionuclide inventory as an element of its PA uncertainty and sensitivity studies. Further, since radionuclide inventory is within the control of DOE (as opposed to bring a subjectively unknown variable), random sampling within a stated range may be inappropriate, and it may be necessary to employ "worst case" assumptions.

b. DOE should reexamine the determination to exclude RH-TRU waste from calculations of underground releases (1992 PA, v. 3, 3-28) as estimates of RH-TRU inventory are refined and canister design assumptions become clearer.

c. DOE must clarify its position as to the time as of which the curie content of TRU waste should be ascertained for purposes of calculating release limits. In a related context DOE has said that the curie content should be determined as of 100 years after disposal. See Final Supplement to EIS, 1990, v. 2, at 18-19. Will such procedure be employed in future PA's?

d. DOE must ensure that its PA analyses conform to waste inventory projections contained in, e.g., its environmental impact statements and other authorizations (e.g., transportation

and RCRA permits) and vice-versa.

8. Repository-waste interactions:

Modeling of the complex interactions among gas generation, repository closure, and brine flow is clearly still in development. Models of particular aspects of these processes are being developed outside of the PA process. Comments prompted by the current state of development are:

a. As to the gas generation model, numerous uncertainties were outlined by Larry Brush at the July 7-9, 1993 meeting between DOE and EPA. Without reiterating these, it should be clear that such uncertainties need to be addressed, either to resolve them or to determine that they are not important.

b. PA should clarify in what sense it is not now possible or practical to use a coupled mechanical and fluid flow model. The transition between the data reported by SANCHO and those employed in BRAGFLO must be made clear. Assumptions employed in the 1992 PA ignore certain factors and should be questioned for conservatism and sensitivity, e.g., representation of porosity changes during decreasing gas pressure; possible differential closure among rooms in a panel; spatial variation in pore pressure and gas generation rate; brine phase in SANCHO; gas escape in SANCHO; constant gas generation rate in SANCHO; creep closure after intrusion (1992 PA, v. 4, 4-15 through 4-20).

9. BRAGFLO modeling

Modeling of brine and gas flow in BRAGFLO raises the following questions:

a. It has been pointed out by EPA (comments at 2/22-25 DOE-EPA meetings) that BRAGFLO assumes a rigid isothermal rock body with no non-Darcy flow and omits consideration of colloids and particulates. Hydrologic properties are symmetrical. Further, whether Darcy's law can be expanded to the continuum modeled by BRAGFLO is not known. In light of these comments, how does DOE propose to justify its conceptual models and support the rejection of alternative conceptual models?

b. Alternative conceptual model uncertainty with respect to relative permeability and capillary pressure is dealt with via a sampling technique (1992 PA, v. 4, 4-24). The supporting Sandia memorandum states that the choice of conceptual models "could be significant" (Webb, at A-149). What approach will be taken better to resolve the uncertainty?

c. The disturbed performance model is scaled to

match the initial excavated volume of a single panel. Such a model assumes effective panel seals. In what way will this assumption be tested in future PA's (see 1992 PA, v. 4, 5-1)?

d. The disturbed performance model extends to the Culebra only. Will more recent strata be incorporated in subsequent PA's?

e. The initial brine saturation of the waste is sampled within the range of 0.0 to 0.14 (1992 PA, v. 4, 5-13; v. 5, 2-9). The PA reports that the 1991 sampling range extended from 0.0 to 0.276, the maximum being the residual saturation that the waste could contain and still comply with transportation requirements. (1992 PA, v. 5, 2-8). For the 1992 PA the sampling range has been restricted due to "numerical constraints imposed by the creep closure model that was implemented by 1992." (1992 PA, v. 5, 2-8). Please explain the numerical constraints. What efforts are under way to replace the arbitrary range with a more accurate figure?

f. Sampling methods admittedly sample correlated variables independently. Will a method be adopted to refine sampling procedures in this respect?

g. The 1992 PA observes, concerning gas and brine migration, that contaminated brine must displace all brine-saturated pore volume in a grid block before it can move to the next grid block (1992 PA, v. 5, 4-14), and that if some of the pore volume is occupied by gas, travel distances must be increased proportionately (1992 PA, v. 5, 4-15). What is being done with regard to this prospect?

10. Borehole model:

The permeability of borehole fill is a sensitive parameter with respect to radiation releases (1992 PA, v. 4, 5-36). PA assumes that initially the drillers place casing and cement and sand plugs (1992 PA, v. 3, 4-4). PA further assumes that the plug conforms to OCD orders, specifying a solid cement plug through the Salado (id.). The figure (1992 PA, v. 3, Fig. 4.2-1) does not depict such plugs. The PA discussion does not indicate the sensitivity of initial borehole plug permeability, and this should be discussed and the assumptions justified, if significant. Also, do the characteristics of silty sand (1992 PA, v. 3, 4-6) reproduce those of a degraded concrete plug?

11. Castile brine reservoir:

Several parameters are sensitive in analyses of human intrusion scenarios:

a. Castile brine pressure is estimated based upon limited (i.e., WIPP-12) wellhead data; the range is derived from the 1989 Systems Analysis (SAND 89-0462), at 3-148, but the data underlying the derivation of the initial pressure base case and range are not set forth.

b. Bulk storativity is another reservoir attribute estimated from WIPP-12 data. Bulk storativity expresses the ratio of fluid discharged to pressure decrease. It seems correct to base estimates on data as to long-term pressure changes when modeling long-term groundwater releases. However, in modeling surface releases, should not short-term pressure changes be the basis for the estimates?

12. Human intrusion probability estimates:

The estimation of the probability of human intrusion will be one of the most sensitive parts of the PA. Draft EPA compliance criteria propose estimation of a rate of intrusion based on historical data. If such process is adopted some of the following comments may be inapplicable:

a. Is it correct to express the frequency of intrusion as a random variable? The likelihood of an intrusion is affected by the information obtained in--and thus the occurrence of--prior intrusions. The nonrandom nature of the second and successive holes may be important at WIPP, where the first hole is quite likely to intersect extractable resources. Is it not more appropriate to use a multilevel probability analysis?

b. The probability of certain scenarios is affected by the fraction of the disposal area overlying Castile brine reservoirs. The PA casts doubt upon attempts to correlate reservoir data points (1992 PA, v. 3, 5-7) and to identify the stratigraphic location of brine reservoirs in the region (Id., 5-10, 5-11). What efforts are underway to narrow these uncertainties?

c. There is a need for an iterative approach to expert judgment estimates of the probability of human intrusion. Performance of this task, like others, ought to improve with practice and refinement.

d. Issue identification--the description of the intrusion scenarios to be considered by experts--can be carried out separately from estimation of probabilities. In such event the questions assigned to different groups must be stated with precision. We do not approve the approach of making overlapping assignments, as appears to have occurred as between the Futures Panel and the Markers Panel.

e. Selection of panel members: Bonano el al., Elicitation and Use of Expert Judgment in Performance Assessment for High-Level Radioactive Waste Repositories (1990) suggests that generalists, specialists, and normative (i.e., expert elicitation) experts be selected for each elicitation. Thus, there is a need to identify the applicable specialties with respect to each issue, a task which was done with inadequate care in the 1990 elicitations. For example, to consider a specific issue of hydrocarbon drilling practices, it seems necessary to consult an oil field geologist or similar industry expert, but this was not done in 1990.

f. Formation of judgments: Members may, in principle, be elicited singly, or in panels of members who perform parallel tasks, or as a team which separately perform parts of a single task. Bonano et al. point out the hazard that members may unconsciously be influenced by one another's judgment (at 42-43). Diversity in scientific backgrounds must be deliberately sought (at 15). Conflicts of interest must be carefully avoided (at 14). The tasks of team members must be clearly defined so that members are confined to their specialty (at 15).

g. Training: Members should be trained in methods to induce an accurate estimate of probabilities and to reduce bias. (at 16-20). The methods include decomposition of an issue into several less complex problems, stating implicit estimates explicitly, and declaring all assumptions.

h. Decomposition of issues: The issue should be decomposed into a decision tree or event tree, including all factors deemed relevant by the members, that will guide the determination of probabilities. Disagreement as to the nature of the appropriate decomposition reflects an aspect of uncertainty.

i. Documentation of elicitation: The "normative expert" elicitator should document the specialist's judgments and any reasoning offered in support. The intuitive conclusion and any intermediate probability estimates should be recorded and compared and the specialist asked to reconcile any inconsistencies.

j. Scenario selection: When the task involves scenario generation, the normative expert shall be required to employ methods of forward induction, i.e., construction of scenarios by creating a forward-looking "event tree", and backward induction, i.e., reasoning backward based on hypothesized performance or nonperformance of the repository and postulating causes.

k. Probability elicitation techniques: Since the probability issue is critical, criteria should direct the use of probability elicitation techniques to generate the probability estimates. These include fractile techniques, whereby members must estimate the .05, .50, and .95 probabilities, and interval

techniques, whereby members must estimate probabilities at various magnitudes of the unknown value.

l. Combinations: Bonano et al. point out that to average probability judgments of different members or teams addressing the same issue would be erroneous, because it would mask the range of uncertainty reflected by the different judgments (at 42-43, 47). In all situations the reported judgments should include the individual members' conclusions.

m. Documentation: There should be a complete record of the elicitation process, including formulation of issues, selection of members, and each stage of the elicitation process. It is particularly important to subsequent application of estimates to make clear what factors were or were not considered in reaching a probability judgment (e.g., general knowledge of WIPP; effect of markers). Further, the reasoning giving rise to probability estimates and any support in other methods of probability estimation should be recorded. As stated, individual members' conclusions should be set forth. Members should be identified by name (at 44-45).

n. In the 1992 PA conversion from drilling rates to scenario probabilities is inadequately explained. Whether in the future separate futures panel "teams" will constitute a "range" to be sampled is not known. If this is done, it must be made clear what team-estimated conditions (e.g., state of technology) are chosen for sampling and why, and exactly which probability (or probability density function) is thereafter selected. Conversion to drilling intensity must be made explicit. We are concerned about the observations by EEG that the realizations in Appendix D of v. 3 are not the actual results of the program described in the Hora memorandum in Appendix A and that the probability of intrusion is reduced to zero after year 300 for the Boston Team (EEG 9/93 comments at 5). It also seems plain that the intrusion rate overall is zero after 2,000 years (1992 PA, v. 4, 2-19). This seems erroneous.

13. Repository/shaft design:

Several questions arise concerning the engineered components of the disposal system:

a. Seal design and performance: Design standards call for MB 139 and other anhydrite layers to be sealed below and above each panel and drift with grout. (1992 PA, v. 2, 2-48). PA should provide a detailed description of the placement and composition of the grout.

b. Preconsolidated salt in seals and backfill is said to consolidate to a median permeability of 1×10^{-20} m^2 within 100 years. (1992 PA, v. 3, 3-14). Reference must be cited for

this permeability figure. Sandia has said recently that permeability of 10^{-18} m^2 or less is necessary to retard gas flow. Experiments have been planned to support such figure but have not yet been conducted. See Nowak et al., Initial Reference Seal System Design: Waste Isolation Pilot Plant (SAND 90-0355), at 27.

14. Culebra flow and transport model:

The following matters deserve attention as to the model of flow and transport in the Culebra:

a. PA uses past climates to limit projected future variability in precipitation. (1992 PA, v. 2, 2-27; v. 4, 6-11). It has been asserted by Professor Roger Y. Anderson (March 16, 1993 comments to EPA) that a broader range of variability then the range of Pleistocene variation is appropriate. Please comment.

b. Modeling assumes no vertical flow above the Salado (1992 PA, v. 2, 2-24). In light of the imprecise knowledge of recharge patterns (1992 PA, v. 2, 2-36, 2-38) the assumption of no vertical flow must be scrutinized (see 1992 PA, v. 4, 6-2). What is planned?

c. Hydraulic conductivity in the Culebra is insufficiently characterized, in that the variability of, and controls on variability of, fracture porosity are not known (1992 PA, v. 2, 2-16, 2-19). What efforts are planned to improve the state of knowledge? Fracture porosity and spacing are sensitive parameters (1992 PA, v. 3, 2-79, 2-81).

d. The 1992 PA notes that the groundwater geochemistry of the Culebra is inconsistent with a north-south flow pattern (1992 PA, v. 2, 2-36). It is stated that as the groundwater flow model is developed and refined, the potential significance of uncertainty in the location and amount of future recharge will be re-evaluated. (1992 PA, v. 2, 2-38). What are the PA plans to resolve, or examine the significance of, this uncertainty?

e. An agreement between DOE and the State requires that radionuclide retardation be demonstrated with experimental data (1992 PA, v. 4, 6-3). Further, PA notes that experimental data as to distribution factors "cannot be extrapolated directly to a complex natural system" (1992 PA, v. 2, 2-30). At the recent NAS WIPP subcommittee meeting it was specifically stated by one member that laboratory data as to distribution factors is no reliable guide to retardation in the field. What are DOE's plans to develop retardation data that both satisfies its agreement with the State and affords scientific reliability? Will tests on site with nonradioactive analogue tracers be conducted (see 1992 PA, v. 2, 2-41)?

f. How will the effect on the Culebra flow field of injection of fluids from the repository via an intrusion wellbore be measured and modeled? (see 1992 PA, v. 4, 6-2).

g. The PA states that there is insufficient information to characterize the vertical variability of flow within the Culebra (1992 PA, v. 4, 6-1, 6-2). Will this issue be explored further? Also, is it appropriate to model the Culebra as a rock body of uniform thickness, and, if not, what improvements are planned? (1992 PA, v. 4, 6-4).

h. The radionuclide transport model is a obviously sensitive parameter (1992 PA, v. 4, 6-3, Ch. 8). How will DOE select among the alternatives for the next PA?

i. The flow and transport model assumes an intrusion over the center of the disposal area. However, the future borehole may be 315 m closer to the subsurface boundary. (1992 PA, v. 4, 6-4, 6-7). Will the parameter of borehole location be changed or sampled in future analyses?

j. The Culebra flow model includes 70 transmissivity fields, which are calibrated to steady-state and transient head data. The exercise generated inconsistencies between the modeled and observed conditions. (1992 PA, v. 4, 6-26). It would seem that the model requires refinement based on data concerning factors, not now incorporated, affecting the observed head data. Is such an effort planned?

k. In the SECO-TRANSPORT model vertical fractures are not incorporated. Should the model be improved in this respect?

15. Cuttings model:

The direct release model -- now confined to releases through interaction of drill bit and string and the repository contents -- raises the following questions:

a. The drill bit diameter is a sensitive parameter under the current PA and is sampled using a cumulative distribution function based on past drilling practice in the Delaware Basin. (1992 PA, v. 4, 7-1). A principal exploration target is gas, and the bit diameter should approximate that used for gas exploration.

b. The model for spallings releases is still being developed. (1992 PA, v. 2, 7-27). We caution against too rigid assumptions as to the practice which would be followed by a driller who encounters a pressurized zone.

c. Based on the Sandia presentation at the

February 22-25 meeting between EPA and DOE, we believe that it cannot be assumed that intruders would soon detect the presence of the repository and discontinue activities. Please comment.

16. Compliance demonstration:

There are certain fundamental issues with the methods of demonstrating compliance which are not addressed:

a. How are the variables which are to be sampled selected from among all others? For example, why is the future waste inventory not sampled as to one or more variables?

b. How is the sufficiency of sampling methods (e.g., range, frequency) evaluated? By what criteria does the occurrence of one or more "outlier" curves dictate a revision in sampling methods?

c. What is the suggested criterion for "reasonable expectation" with respect to the CCDF realizations? What principles, if any, support the selection of mean, median, or a stated percentile?

d. Why is 4/3 the number of variables a sufficient number of vectors to demonstrate the full range of variability in input parameters? Is another number required to generate a relevant mean, median or other percentile? (see 1992 PA, v. 1, 4-14).