Sandia National Laboratories
Albuquerque, New Mexico 87185

December 15, 1987

Dr. Daniel Galson
Repository Projects Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Dr. Galson:

Enclosed is the November 1987 monthly report for FIN A1165. If you have any questions or comments, please feel free to contact me at (FTS) 844-8368, E. J. Bonano at (FTS)844-5303, or P. A. Davis at (FTS)846-5421.

Sincerely,

Robert M. Cranwell

Robert M. Cranwell, Supervisor
Waste Management Systems
Division 6416

RMC:6416

Enclosure

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WM Project: WM-10, 11, 16 WM Record File: A-1165
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A-1165 PDR

PROGRAM:	Licensing-Methodology Assistance	FIN A1165 Task I
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD: 10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT: $248K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE: 844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano P. A. Davis	FTS PHONE: 844-5303 FTS PHONE: 846-5421

PROJECT OBJECTIVE

To assist in the overall development and integration of the licensing assessment methodology.

ACTIVITIES DURING NOVEMBER 1987

No activities

PROGRAM:	Identification and Analysis of Uncertainties	FIN A1165 Task II
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD: 10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT: $495K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE: 844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano P. A. Davis	FTS PHONE: 844-5303 FTS PHONE: 846-5421

PROJECT OBJECTIVE

To identify, analyze, and recommend generic methodologies for treating uncertainties associated with performance assessments of HLW repositories.

ACTIVITIES DURING NOVEMBER 1987

An outline for the review of uncertainty and sensitivity analysis techniques has been formulated and a copy is included for comment by the NRC program manager. This is a draft outline and is subject to change both in response to comments from NRC and Sandia staff working on this task.

PROGRAM:	Probability Techniques		FIN A1165 Task III
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD:	10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT:	$240K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE:	844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano	FTS PHONE:	844-5303
	P. A. Davis	FTS PHONE:	846-5421

PROJECT OBJECTIVE

To identify techniques for assigning probabilities to geologic processes and events.

ACTIVITIES DURING NOVEMBER 1987

Two outlines were produced and are included in this report for review by the NRC program manager. The first is a general outline of the probability techniques report while the second is an outline of the approach we are using to investigate the techniques that are used for individual events and processes.

In addition, preliminary analyses of potentially adverse events and processes related to Resource Exploration, Thermomechanical Effects, and Tunneling and Mining Engineering were conducted. Included in these analyses was the idenification of the effect these events and processes could have on the system and consideration of the factors that need to be considered for each technique that could be used to assign probabilities to each event and process. At the end of the month, work on the topic of climatic changes began.

Included in this monthly report is the internal Sandia memorandumm by Marshall Berman that NRC requested. The paper for Waste Management 88 on probability techniques was withdrawn.

PROGRAM:	Maintenance and Management of PA Codes	FIN A1165 Task IV
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD: 10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT: $75K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE: 844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano P. A. Davis	FTS PHONE: 844-5303 FTS PJONE: 846-5421

PROJECT OBJECTIVE

To provide for a program of computer code maintenance and configuration management for codes developed for the NRC's HLW performance assessment program.

ACTIVITIES DURING NOVEMBER 1987

No activity.

PROGRAM:	Technical Assistance for SCP Review	FIN A1165 Task V
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD: 10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT: $45K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE: 844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano P. A. Davis	FTS PHONE: 844-5303 FTS PHONE: 846-5421

PROJECT OBJECTIVE

To develop internal staff guidance for review of the draft consultation SCP's and final SCP's in the area of performance assessment, to review selected parts of the draft and final SCP's, and to review NRC staff comments on selected parts of the draft and final SCP's.

ACTIVITIES DURING NOVEMBER 1987

Considerable time was spent by staff and contractors in reviewing and editing the SCP review plans. A copy of the last Sandia draft of these plans is included with this monthly report. In addition, below is a list of the personnel who worked on the plans and the specific plans they were responsible for. If there are any remaining questions about the plans, please feel free to contact not only the principal investigators but also those listed below.

SCP REVIEW PLAN	PERSONNEL
Compliance Assessment with the EPA Containment Requirement	Krishan Wahi Robert Cranwell
Scenario Development and Screening	Robert Cranwell Robert Guzowski
Estimating Scenario Probabilities	Robert Guzowski Robert Cranwell
Modeling	Larry Shippers
Expert Judgment	Evaristo Bonano
Model Uncertainty	Larry Shipers

Analysis of Data Uncertainty	Evaristo Bonano Paul Davis
Sensitivity Analysis	Irving Hall Charlene Harlan
Performance Confirmation	Krishan Wahi

PROGRAM:	Short-Term Technical Assistance	FIN A1165 Task VI
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson — BUDGET AMOUNT: $64K

CONTRACT PROGRAM MANAGER: R. M. Cranwell — FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano — FTS PHONE: 844-5303
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PROGRAM OBJECTIVE

To provide, on short notice, general technical assistance on HLW matters related to Tasks 1 through 5 that would not be provided in the normal course of the work in these tasks.

ACTIVITIES DURING NOVEMBER 1987

No activities.

FIN A1165, Task I - Licensing Methodology Assistance
Subcase 1183.010
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.3	0.7
II. Direct Loaded Labor Costs	3	8
Materials and Services	0	2
ADP Support (computer)	0	0
Subcontracts	30	39
Travel	1	1
G&A	4	5
Other (computer roundoff)	-1	-2
TOTAL COSTS	38*	53

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$68K	$248K	None	$180K

*Due to the addition of two new tasks to FIN A1165 in FY88 it has taken longer than initially anticipated to identify the correct tasks to which the costs reported here need to be assigned. We expec to see these changes reflected in the next monthly report.

FIN A1165, Task II - Identification and Analysis of Uncertainties
Subcase 1183.020
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	.2	1.5
II. Direct Loaded Labor Costs	2	19
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	1	2
Travel	3	4
G&A	1	3
Other (computer roundoff)	0	-1
TOTAL COSTS	7	27

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$60K	$495K	None	$435K

FIN A1165, Task III - Probability Techniques
Subcase 1183.030
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year-to-Date
I.	Direct Manpower (man-months of charged effort)	0.1	0.5
II.	Direct Loaded Labor Costs	1	5
	Materials and Services	0	0
	ADP Support (computer)	0	0
	Subcontracts	0	2
	Travel	0	0
	G&A	0	1
	Other (computer roundoff)	0	1
	TOTAL COSTS	1	8

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$120K	$240K	None	$120K

FIN A1165, Task IV - Maintenance and Management of PA Codes
Subcase 1183.040
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.0	0.0
II. Direct Loaded Labor Costs	0	0
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	0
Travel	0	0
G&A	0	0
Other (computer roundoff)	0	0
TOTAL COSTS	0	0

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
None	$75K	None	$75K

FIN A1165, Task V - Technical Assistance for SCP Review
Subcase 1183.050
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.9	1.0
II. Direct Loaded Labor Costs	9	10
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	11	18
Travel	1	1
G&A	2	3
Other (computer roundoff)	1	0
TOTAL COSTS	24	32

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
None	$45K	None	$45K

FIN A1165, Task VI - Short Term Technical Assistance
Subcase 1183.060
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC B
SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.0	0.0
II. Direct Loaded Labor Costs	0	0
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	0
Travel	0	0
G&A	0	0
Other (computer roundoff)	0	0
TOTAL COSTS	0	0

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$19K	$64K	None	$45K

FIN A1165
Total for Case 1183.000
November 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year -to- Date
I.	Direct Manpower (man-months of charged effort)	1.5	3.6
II.	Direct Loaded Labor Costs	15	42
	Materials and Services	0	2
	ADP Support (computer)	0	0
	Subcontracts	42	61
	Travel	5	6
	G&A	7	12
	Other (computer roundoff)	1	-3
	TOTAL COSTS	70	120

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$267K	$1167K	None	$900K

Sandia National Laboratories
Albuquerque, New Mexico 87185

date: August 31, 1987

to: Distribution

Marshall Berman

from: Marshall Berman, 6427

subject: Probability Issues in SARRP and NUREG-1150

In a recent memo [1], three different methods to represent uncertainties in probabilities and physical quantities were reviewed. The authors discussed important flaws in the first two methods. They concluded that the third method was superior and recommended its universal use in all future studies. I support the introspection and analysis conducted by the authors and their attempt to clarify different meanings of probabilities (cf. also Reference 2), although I disagree with some of their recommendations. This memo discusses some practical as well as philosophical ideas that may be of value to future risk analyses.

DEFINITION OF TERMS

Reference 2 clearly distinguishes between two types of subjective probabilities, P_s. P_{sc} represents a person's degree of belief or confidence that a particular outcome will or will not occur; it is frequently equated to the betting odds that the person considers to be "fair" (equal likelihood of winning or losing). P_{sf}, on the other hand, represents a person's estimate or guess of the mean frequentist probability, P_f, that would be determined from a set of future measurements. This distinction is very important in interpreting what the experts really intended to convey in the quantification of their personal opinion probabilities (POPs), as discussed in References 1 and 2.

A similar pair of definitions could be used for uncertainties. U_f is the frequentist uncertainty about the mean of a distribution determined by a finite number of measurements. It is quantified in ordinary statistics by employing some definition of a standard deviation, based on the number of measurements and their spread around the mean. Hence, P_f and U_f have meaning only in the context of a set of measurements. On the other hand, U_s can be defined as the expert's uncertainty in his estimated POP for P_s. (As discussed in Reference 1, U_s has meaning only when applied to P_{sf}; P_{sc} is already essentially identical to U_s, since "degree of belief" is equivalent to "degree of uncertainty" in a betting-odds definition.)

Both U_s and P_s are psychological measures of a person's state of mind; they do not necessarily represent anything in the real world; they can be ephemeral or immutable, rational or emotional. Nevertheless, U_s and P_s are used frequently and ubiquitously in all societies and all economic, cultural and intellectual strata, to make policy and decisions.

Human uncertainty is not inversely proportional to the amount of knowledge on a certain subject. A very common misunderstanding is to equate a wide uncertainty range, even zero to one, to a complete lack of knowledge. On the contrary, increasing knowledge often increases human uncertainty. Among the almost infinite number of supporting examples, let me select the erstwhile belief in the "ether." A POP poll as late as 1880 would have shown that essentially all experts believed in the ether - human uncertainty, U_s, was negligibly small. Subsequent to the Michelson-Morley experiments, uncertainty increased a little. After many decades and much more theoretical and experimental research, U_s increased dramatically; the publication of the special theory of relativity may have coincided with a local maximum in U_s. But even long after Einstein's paper, a POP poll would probably have shown substantial residual support for the existence of a preferred coordinate system. People who believe that this generation is smarter than all previous generations and far less susceptible to making errors, are fools of very high order; e.g., consider some views only a few years ago concerning hydrogen flammability and detonability limits, the threat (let alone the existence) of direct containment heating, the China syndrome, the importance of large-break LOCAs, the need for containment buildings (in the USSR), the need for emergency core cooling systems (in the US), the "probability" of a space shuttle disaster.

Any person, expert or idiot, can supply values for P_s and U_s. Hence, POP polls of "experts" can only have utility if the experts' values of P_s and U_s are superior for some reasons. The reasons could include: special knowledge of the particular subject (although history shows that the most glorified experts have been dead wrong in some of their opinions - Lord Kelvin, Rutherford, Millikan, Edison, Wilbur Wright, Lee DeForest, Ernst Mach, Einstein, etc., etc.); a proven track record based on past predictions of P_{sf} that have subsequently been shown to agree with measured values of P_f (a very fallible reason as demonstrated by the rapid rise and fall of various Wall Street prognosticators); or the demonstration that existing theories and experimental data can be reasonably extrapolated to provide a technical basis for the P_{sf} values.

MEASUREMENT OF HUMAN UNCERTAINTY U_S

History clearly establishes that human uncertainty is not necessarily a guide to reality. Hence, values of U_S at any given time may provide psychological comfort (a "warm feeling" of understanding) rather than a valid assessment of technical understanding. Nevertheless, many decision makers today desire a quantitative measurement of U_S.

One use of U_S might be to prioritize the research that needs to be done to reduce uncertainties. For "legitimate" POP polls (as described in this memo and in the Ten Commandments of POP on pp. 8-9), this could be a useful objective - research needs always exceed the available funding and must be prioritized. Furthermore, errors in judgement in assigning priorities based on POP polls could be corrected later when more information became available.

Reference 1 discusses various methods for measuring and analyzing uncertainties. Method 1 involves treating each POP as an equally weighted data point or level in the Latin Hypercube sampling scheme. Method 2 involves averaging all POPs and using this average to "weight" the occurrence of a probability of either zero or one. They conclude (and I agree) that both of these methods have serious deficiencies. A third method involves breaking up the range (0 to 1 for probabilities) into levels and having the experts provide "weighting factors" for each level. The average weighting factor for each level is then used as input to the LLH scheme. The authors strongly favored Method 3 for both physical quantities and probabilities.

Is Method 3 superior? Reference 1 argues that it allows the experts to distinguish between the two types of probabilities, P_{SC} and P_{Sf}, by clearly employing only P_{Sf}. Given this choice, the experts are now free to produce separate values of U_S without encountering logical difficulties [2]. In fact, Method 3 forces the expert to create complete subjective probability distribution functions, discrete or continuous, without even being constrained to classical distributions such as normal, binomial or uniform! The benefits observed in Reference 1 can be simply attributed to granting permission to an expert to describe in almost unlimited detail his prophecy of the outcomes of future experiments. Is there a scientific justification for ascribing more accuracy or reliability to a detailed multi-valued prophecy compared to a simpler yes-no prophecy? How believable are any prophecies, simple or complex? I believe that the problem is not superiority of one method over another, or the shortage of statistical methods in general, but rather the shortage of needed data.

I know of very few individuals who have successfully predicted the outcomes of new experiments in reactor safety.

It is rare indeed to even come close to predicting a distribution for any previously unmeasured quantity, prior to actual measurements. The history of reactor safety research is replete with examples of a priori predictions that have subsequently been proven completely false.

The substitution of POPs for real data and understanding can be a very dangerous procedure. For example, recent opinion polls have claimed that much of the uncertainty in risk from severe accidents comes from direct containment heating (DCH) issues. This has led some people to favor the inclusion of active or passive depressurization systems in PWRs. I believe that taking such actions now based on POP polls would be extremely foolish and potentially dangerous. Subsequent research on both DCH and other competing risks (increased LOCA probability, increased probability of triggering steam explosions) is essential to demonstrate whether depressurization provides a net increase or decrease in risk.

COMPOSITION OF POP PANELS

A great deal of effort and money has gone into developing methods to quantify human uncertainty. However, the ultimate determination of human uncertainty depends essentially entirely on the composition of the panel of experts (including their number and completeness, their personalities and behavior patterns, degrees of expertise, presence of biases and self interest, veracity, ulterior motives, etc.) and not on the methodologies used for quantifying expert judgement.

Consider a panel formed to quantitatively estimate the probability that God exists. The panel's average POP would simply and only reflect the percentage of agnostics, atheists, and theists in the panel's composition; statistical methodologies would be irrelevant. Systematic exclusion of any of these groups and their viewpoints would drastically change the panel's final probabilities. The same situation would prevail if the panel was asked for the subjective probability of containment failure due to steam explosions, direct containment heating or detonations, or the probability that astrology and graphology are valid predictive sciences. (3000 U.S. firms and 85% of European firms use graphological analysis in hiring, despite the absence of any scientific support [3]; it is also clear that millions of people, perhaps the majority, believe in astrology despite the fact that it is obviously superstitious nonsense.)

More to the point, there is not a single probability produced on any issue addressed by the NUREG-1150 panel members that I could not significantly change by selecting a different set of experts. This is true despite the fact that all new and old panel members would adamantly proclaim their honesty, independence, and lack of bias.

It is conceivable that the public positions of panel members may differ from their private positions. Several factors could produce such a dichotomy including pressures from peers, employers or governments, or fears that certain opinions could be abused, taken out of context, or used for other purposes that the experts oppose; e.g., an expert may believe that the probability of a particular high-consequence event is very uncertain, but that the media or anti-nuclear groups could translate this uncertainty into anti-nuclear rhetoric that the expert would oppose. Fears of abuse would be difficult to alleviate in today's climate of litigiousness and journalistic and political hype. Subtle and not-so-subtle pressures, however, could be partially alleviated by using secret ballots to obtain expert opinions.

REDUCTION OF HUMAN UNCERTAINTY U_S

A major goal of current and future probabilistic analyses is the reduction of uncertainties (as measured by POP polls) concerning severe accidents. How can this be accomplished?

One method would involve replacing some experts who have large uncertainties with others who are less uncertain concerning severe accident issues.

Another method would be to effectively reduce the number of experts by eliminating outliers. This can be done after the experts have been polled, or even prior to their selection. If a particular set of experts is a priori excluded from providing their values of P_S or U_S, then the estimated uncertainty will simply reflect the biases and parochialism of the particular subpopulation.

It is self-evident that U_S must increase (or remain unchanged) if the number of experts is increased, if "coercion" is prevented (i.e., old experts do not change their values of U_S because of the new experts' opinions). However, if the new experts disclose some additional existing information concerning the "technical basis," then old experts could legitimately change their values; however, this would be an admission that the old experts were deficient in their knowledge, and hence were poor (or at least uninformed) experts in the first place.

If, however, the new experts provide information that is new to the entire community, i.e., an advance in the state of the art, then human uncertainties could legitimately be reduced.

POP panels whose composition deliberately excludes certain experts and controversial opinions, regardless of whether their viewpoints are considered overly optimistic or pessimistic, will always underestimate the degree of human uncertainty in the technical community.

History shows that controversy is an integral and essential part of scientific progress. Had POP polls been in vogue over the last few centuries, all science would have suffered severe setbacks. POP polls and the associated processes of averaging inputs, removing "outliers," and ignoring low frequency events would have had catastrophic consequences on scientific progress. Indeed, in low probability events such as severe accidents, the "outliers" may ultimately turn out to be the failed seals that caused the destruction of the Challenger.

If a valid untruncated estimate of U_S is desired, then the expert panel must represent all views of the technical community, or technically justify the exclusion of some of those views. It is clear that there is only one legitimate way to reduce uncertainties: Improve the technical basis supporting the POP values of P_S.

JUDGEMENT: INTELLIGENCE VERSUS POLICY

Policy involves the definition of procedures and actions to achieve certain objectives. Intelligence is defined as the technical basis for formulating intelligent policy.

The use of POP polls is frequently defended by analogy with the need for judgement - as though the two were necessarily related. Judgement is essential and is always exercised in science and engineering (intelligence) and decision making (policy). A serious concern I have is that POP polls are becoming substitutes for judgement, rather than vehicles for improving judgements.

It is legitimate for policy makers to poll the intelligence community concerning an issue; for example: What is the level of confidence (or degree of uncertainty) that the intelligence community has in its ability to predict the probability and consequences of core-melt accidents? An even more important related question would be: What is the technical basis for your subjective degree of belief? An expert panel, representing all legitimate technical views on the various issues, could then be formed and polled. The results, including written technical arguments supporting the POP values, could then be peer reviewed and published. (Note that the technical bases for POPs are almost never included as part of POP polls; indeed, experts are generally not forced to defend their estimates, as they would in any technical journal. In rare instances where technical bases are provided, no peer review is granted. The SERG panel [4] produced arguments that were frequently in error and contradictory; nevertheless, only a small number of true experts were aware of and capable of evaluating the errors and contradictions in this panel's work.)

Another potentially useful poll could address the consequences of errors and uncertainties in POP values or in understanding the underlying phenomena; consequences are generally better understood than probabilities.

An unfortunate feature of POP polls such as NUREG-1150 is the enormous breadth of the issues addressed. This breadth forces the panels to treat particular issues in an extremely shallow and cursory fashion. POP polls could be improved if their scope were greatly reduced and objectives precisely and narrowly defined. This substitution of depth for breadth would also encourage the experts to provide stronger technical support for their POPs, perhaps even conducting some calculations that could be subjected to subsequent peer review.

However, all these polls must be considered as interim measures, not solutions. The essential next step is to evaluate the underlying arguments that justified the POPs, determine the research required to convert opinions and judgements into experimentally validated predictive models, and then conduct that research. However, what actually often occurs is that the largest fraction of available funds is used to conduct more polls, change the panels' compositions, change the methods of averaging, evaluating and manipulating the POPs, and produce yet another new consensus. It is ironic that uncertainties estimated through POP polls can be perpetuated because funds needed to conduct uncertainty-reducing research are diverted to the funding of more POP polls and their associated statistical paraphernalia.

I believe that one of the most important lessons to be learned from the Iran-Contra affair is the danger of mixing intelligence and policy. The veracity of intelligence (in our case, research to produce a technology base) can be significantly tainted and compromised by the influence of policy (in our case, the making of decisions). In my opinion, POP polls epitomize the contamination of intelligence by the pressures of policy, whether overt, covert or even unconscious and unrecognized. It is naive, even downright foolish to believe that experts can avoid the influence of policy, regardless of whether that policy represents nuclear utilities and vendors, organizations conducting severe accident research, laboratories conducting competing research, the US or foreign governments, the Union of Concerned Scientists, other antinuclear groups, or simply the expert's own personal agenda and mission. Decision makers must understand that POP polls will always confuse policy and intelligence because of fundamental aspects of human nature; it is not conservative, and indeed may be very dangerous to place much confidence in the utility of such polls.

SANDIA'S ROLE

I believe that Sandia's role in reactor safety research should be predominantly on the side of gathering and interpreting intelligence. This is the difficult aspect of research, involving our best scientific and engineering talents. Sandia is not uniquely qualified to conduct POP polls. There are hundreds of companies in the country capable of gathering and statistically manipulating opinions, perhaps better than we. Furthermore, research addressing the treatment of POP values is far less important than research that would attempt to prove or disprove the underlying technical reasons that the experts supplied to support and defend their subjective POPs.

It is important to understand that poll taking and evaluating is not synonymous with probabilistic risk assessment. Equating objections to POP polls with rejection of all quantitative risk analysis is patently dishonest and misleading. Developing fault and event trees for plants can clearly be useful to improve safety, and in some cases, to estimate probabilities. The development, validation and application of sophisticated accident analysis codes is also clearly within our purview, whether used for risk analysis, accident prevention, accident mitigation and management, or the design of advanced reactors.

RECOMMENDATIONS

1. Reduce emphasis on and funding for POP polls. A moratorium would not be inappropriate.

2. Increase funding for required experimental and theoretical research needed to reduce uncertainties.

3. If and when future POP polls are conducted, they should adopt the following suggested Ten Commandments of POP:

1. The panel's objectives should be narrowly and precisely defined.

2. Panel members should be acknowledged technical experts in the fields being addressed. No person should be allowed to participate on the panel if his interest is only peripheral or political.

3. The panel composition should represent all known views in the technical community, or scientifically justify in writing the exclusion of certain viewpoints.

4. Two separate polls should be conducted for each question. The first poll should be by secret ballot. The second poll should be public.

5. The public poll must be accompanied by written technical arguments supporting the expert's POP numbers.

6. Panel members should define the nature of their POPs, whether of the type P_{sc}, P_{sf}, or something else.

7. Panel members and non-participating experts should be encouraged to review and criticize the arguments of other panel members with whom they disagree.

8. Methodologies for evaluating and manipulating POP polls should not be allowed to discard outliers.

9. Methodologies should encourage experts to represent their beliefs in the simplest fashion using the smallest number of guessed quantities.

10. Methodologies for soliciting POPs should not encourage or force experts to create complex subjective probability distributions (PDFs) based on prophecies. If PDFs are solicited, they should be normal, uniform, etc. with supporting arguments.

REFERENCES

1. D. C. Williams and W. B. Murfin to Distribution, "Representation of Probability "Issues" in the NUREG-1150 Uncertainty Assessment," July 7, 1987.

2. M. Berman, "A Critique of Three Methodologies for Estimating the Probability of Containment Failure Due to Steam Explosions," Nuclear Science and Engineering, 96(3), pp. 173-191, July 1987.

3. Psychology Today, July 1987, p. 11.

4. Steam Explosion Review Group, "A Review of the Current Understanding of the Potential for Containment Failure Arising from In-Vessel Steam Explosions," NUREG-1116, U. S. Nuclear Regulatory Commission, February 1985.

Distribution:

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TECHNIQUES FOR DETERMINING PROBABILITIES OF EVENTS AND PROCESSES AFFECTING THE PERFORMANCE OF GEOLOGIC REPOSITORIES: RECOMMENDED TECHNIQUES

- Introduction
- Reasons Probabilities Are Needed
    - Regulations
    - Screening events, processes, scenarios
- Probability Techniques
    - Description of each technique
    - Background
    - Examples of how each technique has been used
- Topical Areas (to correspond to chapters in first report)
    - Identification of events and processes for which probabilities are needed
    - Description of each event and process identified
    - Reason(s) for being considered (effects on the system)
    - Discussion of considerations for each event and process
        - Data (availability, distribution, pattern, frequency)
        - Level of understanding of processes involved
        - Availability of models/codes
    - Discussion of factors that may or may not be includable
- Applicability Of Probability Techniques To Each Event/Process
    - Discussion of what is needed for each technique to be used for each event/process (reasons for nonapplicability)
    - Advantages/disadvantages/limitations
    - [Examples?]
    - Deciding between techniques if more than one applicable
    - Special considerations
- Recommendations
    - Recommended technique(s) to use for each event/process
    - Conditions under which the technique can be used
    - Justification for the recommendation
    - Examples
- Summary And Conclusions

Appendices-Site Specific Recommendations

A. Basalt
B. Tuff (work in progress on identifying scenarios)
C. Bedded Salt (scenarios have not been determined)

OUTLINE FOR PROBABILITY TECHNIQUES ANALYSIS

Topic
- Events and processes for which probabilities of occurrence are needed
- Why the event or process need to be considered (effects on the system)
- Considerations
  - data availability
  - data distribution: aerially
    through time
  - patterns in data
  - understanding the processes involved
  - availability of models/codes
  - miscellaneous that may or may not be includable
- For each probability technique
  - what would be needed to use the technique on each event and process
  - advantages/disadvantages/limitations
  - (examples)
  - special considerations
- Recommendations
  - existing techniques(s)/newly developed technique(s)
  - justification
  - example(s)

Uncertainty and Sensitivity Analysis Techniques for Computer Models: A Review

SCP REVIEW GUIDANCE

SNLA → NRC 12/3/87

4.3.49 Review Plan for Compliance Assessment with the EPA Containment Requirement

4.3.49.1 Background and Approach

The overall system performance objective for the repository after permanent closure (10 CFR 60.112) is designed to implement the containment requirement of the EPA Standard* (40 CFR 191.13). The requirement is that a repository protect the public from significant radiation doses by limiting the radioactivity released to the accessible environment for up to 10,000 years after repository closure. It is expected that the SCP will address the containment requirement by: discussing the approaches, identifying the data needs, and presenting hypothetical compliance assessment demonstrations using the proposed methodology. This information is important in evaluating: (i) DOE's understanding of the containment requirement, (ii) the acceptability of the proposed probabilistic approach, and (iii) the adequacy of the plan to provide necessary and sufficient site-specific data that would result in a realistic compliance assessment at the time of license application. Compliance with the containment requirement is to be shown based upon a performance assessment which must include: (1) an identification of events and processes that might affect the disposal system, (2) an estimation of the likelihood of occurrence of these events and processes, (3) an examination of the effects of these events and processes on the performance of the disposal system, and (4) an estimation of the cumulative release of radionuclides, considering the associated uncertainties, caused by all significant events and processes. It is expected that the results of the performance assessment

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*In June 1986, the Commission requested comment on proposed amendments to conform existing 10 CFR 60 with 10 CFR 191. Based on comments received, the Commission prepared final amendments; however, in July 1987, the U.S. Court of Appeals for the First Circuit vacated the EPA Standard and remanded it to the agency for further consideration. Accordingly, the final amendments have not been issued. Because no challenges to the containment requirement were withheld, the staff anticipates that the containment requirement will remain substantively the same. This review plan is based on that assumption. Regardless of whether a CCDF approach or an alternate approach is identified in the SCP, the staff review should ascertain that an acceptable method of consolidating the results of performance assessment has been presented or proposed in the SCP.

will be incorporated into an overall probability distribution of cumulative release to the extent practicable. Such a probability distribution indicates the probability of exceeding various levels of cumulative releases. A common form of displaying a probability distribution is the complementary cumulative distribution function (CCDF) which is one minus the integrated value of the distribution function. Regardless of whether a CCDF approach or an alternate approach is identified in the SCP, the staff review should ascertain that an acceptable method of consolidating the results of performance assessment has been presented or proposed in the SCP.

The staff will review the SCP to assess whether their implementation will result in the information necessary to evaluate compliance with the Containment Requirement. In its review, the staff will review both the plans to use methodologies specified in the SCP and plans to develop such methodologies.

4.3.49.2 Criteria

A. The plans should present the approach for a performance assessment to show compliance with the containment requirement, including:

   1. An identification of events and processes that might affect the disposal system (see the criteria in Section 4.3.50, Review Plan for Scenario Development and Screening).

   2. An estimation of the likelihood of occurrence of these events and processes (see the criteria in Section 4.3.51, Review Plan for Scenario Probabilities).

   3. An analysis of the effects of these events and processes on the performance of the disposal system (see the criteria in Section 4.3.52, Review Plan for Modeling).

   4. The consideration of uncertainties in the estimation of cumulative releases and the significance of these uncertainties (see the criteria in Sections 4.3.55 and 4.3.56, Review Plan for Model Uncertainty and Review Plan for Analysis of Data Uncertainty, respectively).

B. The following specific criteria are needed for a CCDF that is used to present the results of a performance assessment.

4.3.49 (2/3)

1. The scenarios used in generating the CCDF should be mutually exclusive.

2. The sum of the probabilities of these scenarios ~~should~~ MUST be less than or equal to unity.

3. (To be determined). A NOTE WAS SENT IN LATE NOVEMBER RE. THIS

4.3.49.3 Applicable Sections of 10 CFR Part 60

60.112

60.113(a)(1)

4.3.49.4 Other Documents to be Considered

NUREG/CR-3235, Technical Assistance for Regulatory Development: Review and Evaluation of the Draft EPA Standard 40 CFR 191 for Disposal of High-Level Waste

NUREG/CR-4510, Assessing Compliance with the EPA High-Level Waste Standard: An Overview

November 19, 1987

Notes on Revised "Review Plan for Compliance Assessment with the EPA Containment Requirement":

1. Changes marked on page 1 (by NRC) are acceptable.

2. We have added a sentence to address the comment "what should be in the SCP".

3. The sentence added by NRC at the end of the "Background and Approach" is also a positive change and acceptable.

4. We are unsure about introducing any discussion related to EPPM at this stage.

5. With respect to any other <u>specific</u> <u>criteria</u> for a CCDF, there is one that could be added. However, it has to be worded very carefully.

One suggestion is:

<u>Criterion 3.</u> The CCDF (or a family of CCDF's) should incorporate estimated uncertainties in the scenario probabilities. In other words, one or more of the scenarios included in the consequence analysis may have a range (rather than a point value) of probability of occurrence; this range should be considered in constructing the CCDF.

Addenda to Criteria for Containment Requirement (4.3.49)

A. 1. An identification ------. Events and processes can be combined to construct scenarios which may be analyzed if the scenario probability warrents it.

A. 3. An analysis of ------. Effects of events and processes may be estimated by performing multiple deterministic calculations with models or using analytical solutions.

4.3.50 Review Plan for Scenario Development and Screening

4.3.50.1 Background and Approach

To conduct a performance assessment of a disposal site, it is necessary to hypothesize the future states that the disposal system may experience over the time period of interest. Scenario development is aimed at addressing this issue. Scenarios are combinations of processes and events that could initiate or influence the release and migration of radionuclides from the confined waste to humans. Scenario development includes systematic methods for the selection of scenarios as well as an estimation of their likelihood of occurrence.

The scenarios used to evaluate a particular disposal site will depend on the characteristics of that site. However, a general and systematic procedure can be used to identify scenarios for any given site. Such a procedure generally includes (1) an initial comprehensive identification and classification of processes and events, (2) an initial screening to eliminate unimportant processes and events, (3) the formation of scenarios by taking specific combinations of the remaining processes and events, and (4) the screening of scenarios to select a final set for use in site analysis. The classification in Step 1 generally includes natural phenomena that occur independently of the presence of the repository, phenomena resulting from human activity, and phenomena resulting from the presence of the repository. An additional classification to identify anticipated and unanticipated processes and events is also essential in assessing compliance with NRC and EPA regulations. The screening of processes, events and scenarios is generally based on criteria such as (1) physical reasonableness (e.g., "not credible" processes and events as defined by the NRC), (2) probability (e.g., the 10^{-8}/yr probability cutoff as specified by the EPA), and (3) consequences.

Although the term "scenario" is not specifically used by the EPA and NRC, their development is clearly implied in the definition of performance assessment (40 CFR 191.12 and 10 CFR 60.) and in assessing compliance with the containment requirement (191.13). Scenario development is also needed in analyses to assess compliance with the individual protection requirement (191.15) and the ground water protection requirement (191.16) of 40 CFR 191, and the performance objectives of 10 CFR 60 (60.111, 60.112 and 60.113). Scenarios are also needed to assess compliance with 60.134 and are useful in demonstrating the completeness of the analysis and in directing site-characterization activities.

In addressing the topic of scenario development and screening, the SCP is expected to include (1) a statement of DOE's definition of the term scenario, (2) a description of why scenarios need to be developed (e.g., the regulatory basis for scenarios), (3) a description of the methodology that has been or will be used to develop and screen scenarios, (4) evidence that the methodology has been successfully used in the past, and (5) how will the problem of completeness be addressed.

The staff will review the SCP's to determine the adequacy of the scenario development and screening process. In these reviews the staff will evaluate (1) scenarios that are documented in the SCP for use in development of site characterization programs and (2) the scenario development plan proposed for use in licensing.

Criteria

A. The plan should provide a concise definition of a scenario and identify the methodology for scenario development and screening. This methodology should:

   1. Be systematic

      a. The steps of the methodology should be well defined and orderly

      b. The product of applying the methodology should be reproducible

   2. Provide assurance that all relevant events and processes will be considered in the development of scenarios. This assurance can be obtained by the following:

      a. Compare the initial list of events and processes to other available lists (at a minimum, the DOE should use all the siting criteria in 60.122).

      b. Compare the events and processes on the initial list to the site description in order to identify events and processes unique to a particular site that might not be the list

   3. Contain explicit criteria for screening events, processes, and scenarios, and provide justification for these criteria

   4. Ensure the compatibility of scenarios developed for the various components of an overall performance assessment (e.g., waste package, engineered barrier system ...).

5. Clearly identify the areas where expert judgement is utilized or envisioned. Such use of expert judgement should satisfy the criteria of Section 4.3.54.

B. Scenarios developed for the EPA Standard should include anticipated and unanticipated processes and events.

C. Scenarios developed for the EPA containment requirement (191.13) should be mutually exclusive. This is not essential for assessments of other NRC requirements or criteria such as waste package and engineered barriers.

D. Scenario development for the engineered barrier system and waste package should identify anticipated processes and events. (Section 4.3.7).

4.3.50.3 Applicable Sections of 10 CFR Part 60

60.111, 60.112, 60.113, 60.134

4.3.50.4 Other Documents to be Considered

NUREG/CR-1677, Risk Methodology for Geologic Disposal of Radioactive Waste: Scenario Selection and Screening

NUREG/CR-4510, Assessing Compliance with the EPA High-Level Waste Standard: An Overview

4.3.51 Review Plan for Estimating Scenario Probabilities

4.3.51.1 Background and Approach

Closely tied to scenario development and screening is the issue of estimating scenario probabilities. Scenario probabilities generally are determined by combining the probabilities of the specific events and processes that comprise the scenario. In the context of repositories, scenario probabilities are first used as screening criteria for scenarios and later in estimating release probabilities to show compliance with Section 191.13 of 40 CFR Part 191. In addition, probabilities of events and processes can be used to direct data collection and other activities for events and processes that are at or near the "cut-off" probability. Numerical cut-off values have been defined for scenario probabilities to drop a scenario from consideration.

The plan should contain: (1) a statement of why probabilities are needed, (2) a description of what probabilities are needed (for events and processes), (3) an explanation of how the probabilities will be used, (4) a description of what technique(s) will be used to estimate probabilities of events and processes, (5) the criteria required for the use of each technique, and (6) alternative approaches for assigning probabilities when little or no data are available. It should be noted that the techniques used to determine probabilities also are applicable to making the distinction between anticipated and unanticipated events and processes.

The staff will review the SCP to determine the adequacy of the approach for estimating probabilities of important events and processes, and ultimately estimates of scenario probabilities. In its review, the staff will evaluate (1) approaches associated with scenarios documented in the SCP and (2) proposed approaches associated with future scenario development, (3) specific site characterization activities aimed at estimating probabilities of certain events and processes.

4.3.51.2 Criteria

Whereas the least subjective technique should be the most favored, the appropriate technique for probability determination for a particular event or process will depend on the nature of the phenomenon, the level of understanding of the phenomenon, the quantity and quality of the available data, and the appropriateness of the data base for future projections. The nature of a particular event or process may suggest a specific technique, although the available data for a site or the time frame may necessitate the use of another technique.

The plan should contain provisions that will clearly identify the technique used to estimate the probability of each event and process and state the justification for using the technique selected.

A. Criteria for the selection of probability techniques

  1. Frequentist (the use of existing frequency data to directly estimate a probability density function)

     a. Sufficient data exist so that the frequency of or cyclicity in the data can be recognized

     b. Projection of the frequency or cyclicity into the future is reasonable given the nature of the event or process and the time period involved.

  2. Modeling (the use of models of the physical system and a sampling procedure to perform Monte-Carlo simulations to estimate a probability density function)

     a. The physical system is understood well enough that a conceptual model can be developed that incorporates all or most of the available data

     b. The computer code exists or will be developed that can represent the event or process in the physical system

     c. The available data are sufficient that sampling from the data and running Monte-Carlo simulations using the data will produce a realistic probability density function

  3. Axiomatic (the use of a probability model (e.g., Poisson))

     a. Sufficient data exist to determine that the event or process is random in space and/or time

     b. The event or process is likely to remain random during the time period of interest

  4. Subjective (the use of expert judgement) (see Section 4.3.54)

B. The plan should explain how time dependent probabilities will be assessed for scenarios that involve transient phenomena (e.g., volcanism- if the pressure in a magma chamber increases with time, the probability of renewed volcanism also increases)

4.3.51.3 Applicable Sections of 10 CFR Part 60

60.112

4.3.51.4 Other Documents to Consider

NUREG/CR-1667, Risk Methodology for Geologic Disposal of Radioactive Waste: Scenario Selection and Screening

4.3.52 Review Plan for Modeling

4.3.52.1 Background and Approach

Predictive modeling is a procedure for simulating the response of a system. For performance assessment, it is used for estimating the consequences of processes and events that are expected to occur in a repository system. The use of predictive modeling is necessary because it is not possible to ascertain the consequences of all the physical processes relevant to the geologic disposal of high level waste by direct observation. This direct observation, either through field or laboratory experiments, is not possible for all processes because of both the spatial and temporal scales that must be considered to show compliance with Sections 60.111, 60.112, 60.113, and 60.134 of 10 CFR Part 60. While natural analog studies can provide insight to some of the relevant processes over large spatial and temporal scales, these studies cannot be used to resolve all of the pertinent issues and are generally qualitative. Predictive modeling used in conjunction with data from accelerated tests is expected to be used to assist in providing reasonable assurance that the required performance criteria for licensing have been met (see Section 60.101 (a)(2) of 10 CFR Part 60).

Predictive modeling may be divided into two major components, (1) the conceptual model and (2) mathematical model(s). The conceptual model is composed of a set of hypotheses that postulate the behavior of a system. This set of hypotheses includes the identification of physical processes that affect the behavior of the system as well as the definition of the structure, geometry, initial and boundary conditions, and properties of the system. A mathematical model is the mathematical representation of the conceptual model. A mathematical model is normally composed of a set of coupled algebraic, differential, and/or integral equations with appropriate boundary conditions in a specified domain. A solution for the mathematical model may be obtained by analytical, quasi-analytical, and/or computational procedures. When possible, an analytical solution which allows an explicit evaluation is the simplest approach to implement. In a quasi-analytical approach it becomes necessary to use a numerical procedure to evaluate an analytical solution. In the computational approach approximations are normally made to the governing differential equations that allow their direct solution using a numerical and/or analog procedure. The quasi-analytical and computational approaches normally include the development of a computer code to implement the numerical procedures used to generate a solution of the mathematical model(s).

The SCP is expected to propose the use of predictive modeling to aid in repository design, to screen scenarios, and to assess the consequence of certain scenarios. It is also expected that modeling techniques will be applied for both data collection and reduction during site characterization. In many cases it is necessary to use predictive models to transform observable data to a form that is useful in consequence analysis. For data collection activities, predictive modeling could be used for the design of both field and laboratory experiments. Predictive modeling when used in conjunction with sensitivity analysis (see 4.3.57) could also be used to guide the data collection activities of site characterization by identifying important parameters.

During the licensing process, both the predictive models used and the consequences that result from their application will not be accepted without question. Instead, the data and reasoning used to arrive at both the conceptual and mathematical models will be examined to reasonably assure that the predictive modeling approach used has a sound, defensible basis and that other modeling options have been considered (see 4.3.55, Model Uncertainty). To the maximum extent possible, all predictive modeling performed should be supported by field and laboratory tests, monitoring data, and natural analog studies. Also, the predictive models used for data collection and reduction should be consistent with the models intended to be used for consequence analysis. For example, a model based upon porous media approximations should not be used to interpret well test data when the conceptual model for consequence analysis hypothesizes that the site is dominated by fracture flow. Independent analyses will also be performed in an attempt to verify the results of the consequence analysis. To these ends, the discussion on modeling should include a complete description of the physical processes and domain to be modeled, of any mathematical equations and boundary conditions used, and of the analytical and numerical techniques used to solve the mathematical equations.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in 4.2.3 and investigations in 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8. While the predictive models used for site characterization and consequence analysis are site specific, generic criteria are adequate to evaluate the acceptability of the selected predictive models. Therefore no considerations to key site-specific topics are provided.

4.3.52.2 Criteria

A. Conceptual Models

1. Existing data and evidence should support the given conceptual model. Justification for neglecting any contradicting information should be clearly presented or multiple conceptual models should be considered (see 4.3.55, Model Uncertainty).

2. The conceptual models used for data reduction during site characterization should be shown to be consistent with

those intended for use in consequence analysis (see 4.3.56, Data Uncertainty).

3. The role of expert judgement in developing conceptual models should be documented (see Section 4.3.54, Review Plan for Formal Use of Expert Judgement).

B. Mathematical Models

1. The envisioned use of mathematical models to represent a process, a component, or a subsystem of the repository should be documented and justification should be provided to support the decision to use specific mathematical model(s). The assumptions, application(s), and limitations of all mathematical models identified should be discussed and should be shown not to contradict any of the hypotheses embedded in the appropriate conceptual model(s).

2. Mathematical models should not be unnecessarily complex; however, it should be demonstrated that all processes that can affect the model results have been considered and any decisions to omit certain processes should be shown to be technically justified.

3. The analytical formulae and/or computer codes necessary to implement the mathematical model(s) expected to be used should be identified. If certain formulae and/or computer codes do not currently exist, plans to develop the capability to implement the appropriate mathematical model should be described and shown to be adequate. The assumptions, application(s), and limitations of all computer codes identified should be discussed and should be shown to implement properly the appropriate mathematical model(s). Also, the selection of a specific computer code (particularly when more than one is available) should be justified.

4. Mathematical models used or proposed should be shown to be validated to the extent practicable, and computer codes should be verified and benchmarked.

5. Computer codes to be used in the modeling effort should be shown to be subject to quality assurance and available for public use (see Review Plan for Quality Assurance).

C. If a sequence of conceptual and/or mathematical models is used to represent a subsystem, a procedure to aggregate the results for the subsystem performance should be described and shown to properly link the subsystem responses both spatially and temporaly.

4.3.52.3 Applicable Sections of 10 CFR 60

60.101
60.111

60.112
60.113

4.3.52.4 Other documents to be considered

R.G. 4.17, Section 8.2.3

NOTE - NO CHANGES MADE TO THIS SECTION - WATCH REFERENCES TO SECTION #s

Example of finished Review Gu draft #3

846-0095 844-4052

4.3.54 Review Guide for Formal Use of Expert Judgment

4.3.54.1 Background and Approach

The formal use of expert judgement is a systematic, documented technique for eliciting and reporting the opinions of experts who have been selected and who have worked according to methods that are generally accepted in the scientific literature on subjective judgement. The formal use of expert judgement is highly structured and is intended to be a way of closing gaps in data or other information. It is not the same as the routine use of expert judgement that is part of any scientific or engineering investigation or design process. The formal use of expert judgement should also be distinguished from the formal use of peer review, another process in which expert panels are used (section 4.3.46). Unlike peer review, the formal use of expert judgement is directed toward closing a data or information gap rather than critiquing the way in which such a gap is closed. As with peer review, the formal solicitation and use of expert judgement should be a documented process.

The SCP is expected to include the formal use of expert judgement in the development of the plans as well as in their implementation. ~~Formal~~ This formal use of expert judgement ~~may~~ might have been applied to (a) set priorities for the collection of site-specific information, (b) formulate hypotheses that are the basis for site characterization activities or (c) determine the level of resources that should be allotted to reducing uncertainties. ~~Formal~~ Also, formal use of expert judgement ~~may~~ might be applied to estimate quantitative values of certain parameters or draw qualitative conclusions when other approaches cannot provide answers.

Finally, formal use of expert judgement ~~could~~ might play a major role in the interpretation of data (including the determination of distributions of parameters), assignment of probabilities of occurrence to scenarios, and the formulation and validation of conceptual and mathematical models, to name a few.

During the licensing process, results of the formal use of expert judgement will not be accepted without question. Instead, the facts and reasoning used by experts to reach their conclusions will be examined independently. In reviewing the SCP, the staff will determine whether the formal use of expert judgement is proposed or was applied only when more objective approaches were found to be unavailable. Where such approaches are shown to be unavailable, the staff should determine whether formal use of expert judgement was applied or is proposed to be applied in a manner that will yield an adequate basis for NRC staff review of the license application. ~~In particular, the review should examine (1) the context in which experts were selected, (2) the problems addressed by experts, (3) the presentation of these problems to the experts, (4) the evidence provided to the experts, and (5) the reasoning used in closing gaps in data and information.~~

Repetitive, summarizes criteria below

Being deleted

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in 4.2.3 ? and investigations in ? 4.2.4 to review appropriate portions of SCP Chapter 8. ? Existing information in Chapters 1-7 relevant to the criteria given below and any staff concerns ? regarding this material should also be considered in the review of Chapter 8. Generic criteria are entirely adequate for this topic, therefore no ? considerations relative to key site-specific topics are provided.

4.3.54 (2/8)

4.3.54.2 Criteria

The formal use of expert judgement in preparing the plan and in the site characterization program should meet the following criteria.

A. In general, the formal use of expert judgement should provide the sole basis for a determination only when other sources of information such as experimental data, quantitative analyses, and historical data are not reasonably obtainable.

B. The formal use of experts in the preparation of the SCP should be documented~~. This documentation~~ and should emphasize the substantive knowledge of the experts. For example, experts used to formulate the aspects of the plan related to hydrology should have an adequate background on the geohydrology of the site. This criterion is a minimum criterion for the formal use of expert judgement in developing the plan. To the extent that development of the plan does not comply with the criteria below, the staff may comment on concerns that may significantly affect the outcome of the plan.

C. The plan should provide for the identification of problems to be resolved through the formal use of expert judgement.

   1. Problems to be resolved by experts should be explicitly identified. The importance of these issues should be stated.

2. The reasons that particular problems were identified for resolution by experts should be stated. The reasons that alternate approaches were not adopted should be presented to provide assurance that the formal use of expert judgement was not adopted when other approaches, such as data collection, were available.

D. The plan should describe the methodology to be used in the decomposition of problems. This methodology should include:

1. A description of the scope of the problem addressed by experts.

2. A technique to assure that the problem is well formulated and tractable. Also, assurance should be provided that all important aspects of the problem have been included.

3. A description of the approach to decomposing the problem into subproblems. Also, the procedures to integrate the answers from each subproblem to provide an answer for the overall problem should be documented.

E. The plan should describe the criteria for selecting experts. These criteria should address:

1. The experts substantive knowledge of the problem and the manner in which the experts gained this knowledge.

2. Coverage of all technical areas of expertise relevant to the problem.

   a. For groups of experts, information regarding whether the groups are multidisciplinary should be included and the disciplines represented should span the entire spectrum required by the scope of the problem. The approach used to aggregate the opinions of the experts should be described.

   b. When a single expert is used, the methods and/or techniques used to assess the expert's recommendation should be presented.

F. For evidence presented to experts,

1. It is likely that some data will be available to experts as a basis for developing opinions or recommendations. The nature of the data (quantitative vs. qualitative) and the source of the data (laboratory vs. field; actual site vs. generic site) should be identified.

2. Sufficient time should be made available to the experts for examining and properly using the data.

G. The methodology for eliciting and applying expert judgment should be discussed in detail. Assurances should be provided that the approach is logical and systematic such that the procedure for arriving at a given estimate can be traced to its source.

4.3.54 (5/8)

1. The approach to provide the necessary normative training (training in techniques for treating uncertainties and estimating probabilities) to experts to assure that they can incorporate uncertainties in their estimates should be addressed.

2. If the experts did not reach a consensus, the approach to resolve different opinions and to present dissenting views should be documented. Dissenting views should not be suppressed.

3. The method for encouraging the experts to find evidence contradicting their views should be documented.

4. The approach used for minimizing systematic bias in obtaining estimates should be presented.

5. The reasoning used by the experts to arrive at their estimates should be documented.

H. Whenever possible, the plan should provide for the calibration of the estimates made by experts. Calibration techniques should include:

1. A feedback mechanism for the calibration of estimates by experts against data collected during site characterization.

2. The use of new data to refine estimates (test assumptions and reduce uncertainties) or to result in new estimates (provide for alternative interpretations).

4.3.54.3 Applicable Sections of 10 CFR Part 60

60.101	60.131
60.111	60.132
60.112	60.133
60.113	60.134
60.122	60.135
60.130	

4.3.54.4 Other Documents to be Considered

Annotated Outline for Site Characterization Plans, OGR/B-5, April 1987

Standard Format and Content of Site Characterization Plans for High-Level Repositories, Revision 1, March 1987.

Summary of NRC/DOE Meeting on Level of Detail for Site Characterization Plans, May 8-9, 1986.

A. Mosleh, V.M. Bier, and G. Apostolakis, "Methods for the Elicitation and Use of Expert Opinion in Risk Assessment, Phase I," USNRC Report, NUREG/CR-4962,

4.3.54 (7/8)

August 1987. Available for purchase from National Technical Information Service, Springfield, Virginia 22161.

M.A. Meyer, and J.M. Booker, "Sources of Correlation Between Experts: Empirical Results of Two Extremism," USNRC Report, NUREG/CR-4814, April 1987. Available for purchase from National Technical Information Service, Springfield, Virginia 22161.

Summary of the Briefing on the DOE Issue Hierarchy and Issue Resolution Strategy, October 8 & 9, 1987.

4.3.54 (8/8)

4.3.55 Review Plan for Model Uncertainty

4.3.55.1 Background and Approach

Model uncertainty is the uncertainty that is introduced during the formulation of the conceptual and the formulation and implementation of the mathematical models (see 4.3.52) of the system. The formulation of a conceptual model introduces uncertainty in several ways. First, during the formulation of the conceptual model it is necessary to make certain simplifying assumptions about the behavior of the real system so that it can be represented with a tractable mathematical model. Due to the complex couplings that can exist between the various physical processes in the real system, the possibility exists that the mathematical model that results from these simplifying assumptions is no longer an adequate representation of the real system. Second, insufficient data describing the real system or its various subsystems forces certain assumptions about their behavior. For example, if a unique geologic layer can be isolated in two adjacent boreholes the assumption that this layer is continuous between them is normally made. But if an undetected fault exists in the region between these boreholes this assumption of geologic and/or hydrogeologic continuity can be invalid. Third, in many cases not all of the available data support a single conceptual model. An example of this would be when head measurements imply a gradient in one direction but groundwater density data imply flow in a different direction. Finally, significant data describing the behavior of the real system may be discarded by the analysts due to their preconceived notions about the system. Conceptual model uncertainty, which is uncertainty associated with the use and interpretation of the data, should not be confused with data uncertainty (see 4.3.56).

Uncertainty can be introduced into the mathematical model in both its formulation and implementation. Lack of understanding of the conceptual model and the physical processes associated with it can result in the introduction of uncertainty in the formulation of the mathematical model. This is further complicated by the difficulties that can be encountered in measuring the representative parameters required by the mathematical model. This is illustrated by the use of a retardation coefficient based upon a simple distribution coefficient in many of the past and current transport analyses. The distribution coefficient is a quantity that is easily measured in the laboratory that lumps all of the complex processes associated with sorption into a single parameter. The limited capability of mathematics to represent complex processes and their couplings can also introduce uncertainties into the formulation of the mathematical model. For example, if it is conceptualized that the groundwater flow at a site is fracture dominated, it becomes necessary to formulate an appropriate mathematical model of fracture dominated groundwater flow. While it is conceivable that a mathematical model based upon some realization of a discrete fracture system could be constructed, this type of flow system is normally represented with the concept of dual porosity. The dual porosity concept is a simplifying assumption where the fractures and rock matrix are treated as two separate but coupled porous media. This simplifying assumption may result in the mathematical model not realistically representing the conceptual model. Extrapolation into time and space of small scale and/or accelerated experimental results can introduce uncertainty into both the mathematical model and its implementation.

If the mathematical model is implemented in a computer code, additional opportunities for the introduction of uncertainty occur. Coding errors can result in computational results which are not representative of the mathematical model. Computational limitations can also result in simulations that are not representative of the mathematical model. This could, for example, result from a coarse discretization forced by limited computer memory that does not realistically represent the physical properties of the system. Also, in many cases simplifying assumptions are applied to the mathematical model in an effort to enhance computational efficiency. User error can also be a major source of uncertainty when computer codes are used to implement a mathematical model. This user error can be in the form of improper application of the computer code as well as data input errors and errors in the interpretation of the computational results. The quantification and reduction, to the extent practicable, of uncertainty is critical in assessing whether the plans proposed will be sufficient to demonstrate compliance with the requirements in 10 CFR 60. These requirements pertain to all modeling activities; in particular, to the estimation of cumulative radionuclide releases, ground-water travel time, and radionuclide release rates from the engineered barrier system.

The SCP is expected to address uncertainty associated with the formulation of conceptual models and the development and implementation of mathematical models. Site characterization activities should be expected to be based largely on hypotheses regarding the behavior of the system (conceptual models) and the representation of the system mathematically (mathematical models). The indentification and quantification of model uncertainties associated with both the data collection and data reduction activities of site characterization and the consequence analyses associated with performance assessment should be considered in the SCP.

The staff should review the SCP to determine whether or not modeling uncertainties have been addressed adequately in the plans. The review should emphasize the manner in which uncertainties in the formulation of conceptual models and the formulation and implementation of mathematical models are going to be treated and what their potential impact on performance assessment could be. Specifically, the data and reasoning used to arrive at the conceptual and mathematical modeling should be examined to ensure that the stated conceptual model and mathematical models are both complete and consistent. All of the available data should support the given conceptual model(s). If contradictory data exist, justification for neglecting this data should be clearly stated or multiple conceptual models should be considered. All assumptions embedded in the formulation and implementation of the mathematical model(s) should be examined to ensure that they do not violate any of the hypotheses embedded in the appropriate conceptual model(s).

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in 4.2.3 and investigations in 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8. Generic criteria are adequate to evaluate the acceptability of the selected predictive models, therefore no considerations to key site-specific topics are provided.

4.3.55.2 Criteria

Model uncertainty includes uncertainty in conceptual models, mathematical models, and computer codes. The SCP should address each of these areas and the plans should be reviewed with respect to the following criteria.

A. The plan should identify the areas of uncertainty in the development of conceptual models.

   1. The simplifying assumptions made when considering natural processes and conditions should be clearly stated and shown to be consistent with the observed behavior of the real system.

   2. Any interpolation, extrapolation, and interpretation of available data (see Section 4.3.56) should be described and shown to be consistent with the conceptual model of the system.

B. The plan should describe the potential effect of multiple conceptual models on the estimated consequences and include a procedure to combine these effects. This procedure should be shown to adequately and appropriately account for the combined effects of multiple conceptual models.

C. The plan should include provisions for identifying potential sources of uncertainty in the development of mathematical models.

   1. Any simplifying assumptions should be shown to be a correct mathematical representation of the appropriate physical process(es)

   2. Any linearization of a nonlinear process should be shown to adeqautely represent the appropriate process in the range of parameters and data of concern.

   3. The treatment of couplings between processes should be shown to represent the appropriate response of the couplings in the real system.

4. The treatment of the interdependence of parameters and temperature dependence of physical properties should be shown to be consistent with the responses observed in the real system.

D. The plan should include provisions for identifying the potential sources of uncertainty in the development and use of computer codes.

1. All computer codes used should be verified and benchmarked in an application similar to their intended use to minimize coding errors during development of the code.

2. Strict procedures to minimize and/or eliminate input errors during use of the code should be clearly outlined.

3. The assumptions embedded in a computer code should be clearly stated and should be consistent with its intended application in order to avoid any misapplication of the code.

4. Results of computer simulations codes as well as their interpretations should be presented.

E. The plan should document approaches used for addressing uncertainty in model results.

1. A complete description of the approach(es) used for addressing uncertainty in model results should be given and shown to be adequate.

2. The sources of uncertainty in the results should be identified.

3. A quantification of the uncertainty in results should be given and shown to be adequate.

F. Existing verification, validation, and benchmarking studies of models should be discussed and assessed. Planned verification, validation, and benchmarking activities for models where the current body of work is either inadequate or nonexistent should be described.

1. A description of what components of the model are to be tested should be given.

2. A statement of when the tests are to be conducted relative to other site characterization activities should be included.

3. Consideration should be given to conducting tests which have the potential to invalidate the proposed model.

4. Plans for evaluating other models should be included.

5. Plans to account for the possibility of having more than one equally plausible model should be stated.

6. Multiple approaches to model validation, including natural analog, field, and laboratory studies as well as expert opinion, should be considered and discussed.

7. A discussion of the effect on the overall site characterization if a model is invalidated should be included.

4.3.55.3 Applicable Sections of 10 CFR 60

60.101(a)(2); 60.101(b)
60.131(b)(4)
60.131(b)(7)

4.3.55.4 Other Documents

NUREG/CR-3097 Benchmark Problems for Repository Siting Models

NUREG/CR-3636 Benchmark Problems for Repository Design Models

NUREG/CR-3451Benchmark Problems for Radiological Assessment Codes

Note: Read 60.101

4.3.56 Review Guide for Analysis of Data Uncertainty

4.3.56.1 Background and Approach

To a lesser degree, uncertainty in the data for the engineered components of the repository system may also be expected.

Data uncertainty is the lack of complete assurance that the information about a given site is representative of the conditions of the site. This uncertainty arises from: 1) possible imprecision or error in the instruments and techniques used to obtain primary data (for example, water pressure); and 2) possible errors in interpretation and analysis of the primary data in arriving at "reduced" data (for example, hydraulic conductivity). Data uncertainty is not to be confused with uncertainties arising from the use or interpretation of the data such as spatial interpolation of the data (i.e., contouring or kriging the data) or assigning probability distributions to the data. These are conceptual model uncertainties (See section 4.3.55 Model Uncertainty). Also data uncertainty should not be confused with naturally occuring variability in the data.

The SCP is expected to include a description of the sources and types of data uncertainty along with plans to quantify and reduce this uncertainty where ever possible. The SCP should also be expected to deal with uncertainty in data (directly or indirectly) in the assignment of levels of confidence to performance goals. Some performance goals such as the values of hydraulic parameters which are likely to be estimated directly from experimentations tests will be directly impacted by the uncertainty associated with the measurements. Other performance goals may be estimated with models requiring parameters that are to be measured. The estimates of these performance goals will be influenced by the uncertainty in the models (see Section 4.3.55) and in the values of the parameters these models require. In addition, the SCP should be expected to propose methods for treating and, to the extent possible practicable, reducing uncertainty in the collection of data that are used in formulating conceptual and mathematical models.

4.3.56 Pg 3 of 6

(SEE INSERT #1)

4.3.56 Review Plan for Analysis of Data Uncertainty

4.3.56.1 Background and Approach

The SCP should be expected to deal with uncertainty in data directly or indirectly in the assignment of levels of confidence to performance goals. Some performance goals such as the values of hydraulic parameters which are likely to be estimated directly from experimentations will be directly impacted by the uncertainty associated with the measurements. Other performance goals may be estimated with models requiring parameters that are to be measured. The estimates of these performance goals will be influenced by the uncertainty in the models (see Section 4.3.55) and in the values of the parameters these models require. In addition, the SCP should be expected to propose methods for treating and, to the extent practicable, reducing uncertainty in the collection of data for formulating conceptual and mathematical models, and inferring values and/or distributions for parameters needed in the models to be used in the resolution of issues and the preparation of a license application.

The quantification and reduction of uncertainty is important in the assessment of whether the plans proposed in the SCP will be sufficient to demonstrate compliance with the requirements of 10CFR60. These requirements pertain to the estimation of cumulative radionuclide releases, ground-water travel time, and radionuclide release rates from the engineered barrier system using models. Uncertainty in the collection, interpolation, and use of data in model development or as input to models and computer codes is an important component of overall uncertainty.

The staff should review the SCP to determine whether or not the major sources of uncertainty in data have been identified and considered in the development of the plan as well as in its implementation. Particularly, the review should emphasize the determination of the acceptability of approaches proposed to (1) quantify uncertainty, (2) estimate the relative importance of unquantifiable uncertainty, and (3) reduce uncertainty. (see section on Sensitivity Analysis, 4.3.57)

4.3.56.2 Criteria

A. The sources of uncertainty in data used to develop conceptual models, and/or as input to mathematical models and computer codes should be identified. The most important sources of data uncertainty that should be addressed in the plan are:

1. Measurement errors caused by
   (a) incorrect use of a given measuring technique
   (b) statistical bias of the measurement

2. An incomplete understanding of the Spatial variability of data. ~~and the use of lumped parameters to represent such data~~.

3. Misinterpretation of data caused by incorrectly assuming *a priori* the conditions of the system, and/or by using indirect observations to infer values of parameters.

4. Extrapolation and/or interpolation of data.

5. Reduction of data to obtain interpreted parameters such as hydraulic conductivity

B. ~~The measurement of data should consider the following:~~ The determination of the uncertainty of the data should include:

1. adequacy of measuring technique

2. reliability of instrumentation under adverse environments (e.g., elevated temperatures)

3. sampling bias due to spatial distribution and number of observations, location of the observation, and duration of tests.

4. test conditions representative of expected repository conditions

C. The extrapolation and/or interpolation of data to address spatial distribution and/or gain insight on conditions not covered in experiments should be based on:

1. The use of well-established techniques (e.g., such as, kriging for interpolation).

2. The availability of sufficient data for adequate use of a selected technique in order to minimize spurious behavior.

D. The plan should describe the proposed use of data-reduction techniques. Justification should be provided for the use as well as sufficient evidence that other more direct means of measuring given parameters are not available. Data reduction should consider the following:

4.3.5.6 Pg 6 of 6

2. In stochastic techniques, a stochastic governing equation is developed by introducing the mean and variance of uncertain quantities) into the deterministic governing equation. The mean an variance of the system response is then directly determined by the solution of this stochastic governing equation.

1. Use of accepted techniques

2. Use of techniques that would minimize the introduction of errors.

E. The plan should describe existing or proposed techniques that will be used to quantify uncertainty in data resulting from:

1. Measurement errors

2. Extrapolation and Interpolation of Data

3. Data Reduction

For sources of data uncertainty that cannot be quantified such as misinterpretation of indirect measurements or misapplication of specific measuring techniques, the plan should describe and justify the approach and/or techniques to be used in assessing the uncertainty introduced and provide an indication of the relative importance of such uncertainty.

Statistical and stochastic technique are two examples of ~~A~~cceptable approaches for quantifying data uncertainty. ~~include:~~

~~1. Statistical techniques~~
~~2. Stochastic techniques~~
~~3. Interpolation techniques~~
~~4. Differential analysis techniques~~

The selection of a given technique should be based on the plans to collect sufficient supporting data. For example, if statistical techniques are to be used, sufficient data need to be collected to determine ranges and to estimate distributions of variables. If stochastic techniques are to be used, sufficient data are needed for inferring spatial correlations.

F. The plan should describe the approaches selected or proposed to reduce uncertainty in data. Specifically, evidence should be provided that:

1. the conceptualization of the system on which data collection is based has been tested (e.g., a technique based on an isotropic porous medium should not be used to measure hydraulic conductivity in an anisotropic medium)

2. The measuring technique is used correctly and the statistical bias can be minimized.

~~Statistical technique~~

1. In statistical techniques, a range and distribution of an uncertain parameter(s) is specified and a distribution of the system response is ~~determined~~ Estimated by sampling the uncertain parameter(s) and performing multiple simulations with a deterministic model.

3. The scale of the measurement is adequate for the intended use of the data (e.g., laboratory measured dispersivities should not be used to gain insight on transport over large spatial scales).

4. Sensitivity analyses are used to identify the most important parameters so that data collection should emphasize these parameters. See Section (4.3.57)

5. Measurements for important parameters should be based on multiple techniques, to the extent practicable.

4.3.56.3 Applicable sections of 10 CFR 60

60.101(a)(2)

60.113(b)(4)

60.131(b)(7)

4.3.56.4 Other Documents to be Considered

REPLACE WITH INSERT

4.3.57 Review Guide for Sensitivity Analysis

4.3.57.1 Background and Approach

In the SCP, it is expected that the results of sensitivity analyses will be used in guiding and prioritizing site characterization activities and model development, and in the assessment of the importance of uncertainty in parameters and models. The primary goal of sensitivity analysis is to identify the principal contributions ~~to the~~ uncertainty in the results of a performance assessment. Since 60.101(a)(2) requires that reasonable assurance be provided that the engineered barrier system and the geologic setting conform with performance objectives and criteria, an important component of the site characterization plan should be the identification of the important sources of uncertainty. Site characterization activities should be aimed at generating the necessary information that will allow the quantification, treatment, and/or reduction of uncertainties. The staff will review the plans to determine the purpose, applicability, and completeness of sensitivity analyses used or proposed, and the role they play in the issue resolution strategy.

The detailed criteria below should be used in conjunction with the general review criteria for parameter identification in 4.2.3 and investigations in 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information in Chapters 1-7 relevant to the criteria given below and any staff concerns regarding this material should also be considered in the review of Chapter 8.

REPLACE WITH INSERT

Generic criteria are ~~entirely adequate for this topic~~, therefore no considerations relative ~~to key~~ site-specific topics are provided.

4.3.57.2 Criteria

The use of sensitivity analyses in the preparation and proposed implementation of the plan should satisfy the following criteria

A. The objective of the sensitivity analysis should be clearly stated. The sensitivity analysis should be used to:

1. Identify important parameters ~~sources of uncertainty~~. What parameters most influence the results? Do those parameters have uncertainties associated with their values? (See Sections 4.3.55 and 4.3.56)

2. Guide site characterization activities. Influential parameters must be considered for measurement and quantification.

3. Identify modeling needs. Concentrate on the important parameters in model development.

B. The approach used for the sensitivity analysis should be described. The description should include the following, all of which should be shown to be applicable to the objective of the analysis.

1. Techniques used and the procedure to apply the techniques

2. The rationale for selecting the technique(s)

3. Inherent assumptions and limitations of the selected technique(s)

4. Method of presenting results of the sensitivity analysis

Remove this section - see Background for reason

~~C. If the purpose of the sensitivity analysis is to identify important sources of uncertainty, the plan should describe how modeling uncertainties are distinguished from parameter and data uncertainty.~~

C ~~D.~~ For sensitivity analyses to identify important variables the following criteria should be met:

1. Determine the importance of the variables ~~The criteria for deciding on the importance of variables~~ (i.e., ranking of variables)

2. ~~The nature~~ (STET) of the model used (i.e., complex vs. simple models; bounding models)

3. Use validated models ~~Validated models should be used~~ to the extent practicable. If model(s) that have not yet been validated are used, the technical basis for using these models should be stated. For example, a verified model may be acceptable where validation is not possible due to lack of measured data. ~~Validation means~~ A validated model is capable of reproducing and predicting physical processes. A verified model has been tested to show that its submodels have been properly implemented (ie., results compare favorably to known analytical solutions).

These are NRC definitions of 'verification' and 'validation'

Use
4. ~~The~~ ranges of values of variables considered in the sensitivity analysis that are ~~should be~~ representative of expected repository conditions.

D. ~~E.~~ Sensitivity analysis for identifying important processes and the impact of the modeling of these processes should be described in terms of:

1. The physical reasonableness of these processes

2. The nature of the models used for these processes

3. The validity of these models

If unvalidated models are used, the justification for using these models should be stated. The ranges of value of parameters governing these processes should be representative of expected repository conditions.

E. ~~F.~~ The scale at which the sentivity analysis is ~~are~~ performed should be described. If sensitivity analyses are performed or proposed for subsystems, a rationale should be provided as to the adequacy of these analyses with respect to identifying important contributors to overall system performance.

F. ~~G.~~ If the sensitivity analyses are aimed at guiding and prioritizing site characterization activities, the applicability ~~validity~~ of model(s) and ranges of values of parameters in those models should be justified.

(an alternate model based on the results of a sensitivity analysis)

G. H. If a replacement model ~~resulting from a sensitivity analysis~~ is used to make inferences about the relationship of independent and dependent variables the accuracy of the replacement model should be determined including a rationale for the criteria used to establish such accuracy.

4.3.57.3 Applicable Sections of 10 CFR 60

60.101

4.3.57.4 Other Documents to be Considered

NUREG/CR-2350, Sensitivity Analysis Techniques: Self-Teaching Curriculum

NUREG/CR-2452, Risk Methodology for Geologic Disposal of Radioactive Waste: Final Report

NUREG/CR-3904, A Comparison of Uncertainty and Sensivity Analysis Techniques for Computer Models

4.3.57 Review Guide for Sensitivity Analysis

4.3.57.1 Background and Approach

Sensitivity analysis is a methodology for identifying and assessing the importance of the variables ~~which~~ that ~~effect~~ affect the site performance parameters. Potentially many variables can influence the values of the performance parameter(s); however, not all of these variables will have a large impact on the performance values. It is the goal of sensitivity analysis to identify the important ones. Sensitivity analysis should not be confused with uncertainty analysis. Uncertainty analysis involves the estimation of the probabilistic properties of the performance variables (i.e. in the containment requirement of EPA Standard 40-CFR191, the uncertainty analysis involves estimating the CCDF of the normalized EPA sums) whereas sensitivity analysis involves determining the variables that influence performance parameters and their distributions.

The SCP is expected to produce results that will guide and prioritize site characterization activities. ~~These results~~ This effort should include a sensitivity analysis which will hopefully give guidance on where resources should be expended. ~~Since~~ Because 60.101(a)(2) requires that reasonable assurance be provided that the engineered barrier system and the geologic setting conform with performance objectives and criteria, an important part of the SCP should be the identification and quantification of the variables that ~~effect~~ affect the performance variables of a given site. Thus, the primary goal of a sensitivity analysis is to do this identifying and quantifying. The purpose of sensitivity analysis is not to assess model uncertainties ~~which~~ that are discussed in

4.3.57 Pg 7 of 7
(INSERT (Pg 2 of 2))

4.3.55 or data uncertainties which are addressed in 4.3.56

During the licensing process, the results of a proper sensitivity analysis can be used for guidance in resource allocation ~~where to allocate resources~~. For example, if a sensitivity analysis indicates a certain variable is very important for estimating a performance parameter and values for this variable are not well known, it may be wise to expend some resources in obtaining information on this variable. Typically this effort would include collecting data to reduce the uncertainty in a certain variable or group of variables. It is assumed the staff will review the plans to determine the purpose, applicability, and completeness of the sensitivity analyses used or proposed, and the role they play in the issue resolution strategy.

The detailed criteria below should be used in conjunction with the general criteria for parameter identification in 4.2.3 and investigations in 4.2.4 to review appropriate portions of SCP Chapter 8. Existing information in Chapters 1-7 relevant to the criteria given below and any staff concern regarding this material should be considered in the review of Chapter 8. Generic criteria are entirely adequate for this topic, therefore no considerations relative to key site-specific topics are provided.

4.2.4.11 REVIEW PLAN FOR PERFORMANCE CONFIRMATION

4.2.4.11.1 Background and Approach

Performance Confirmation is the process of measuring parameters, responses (e.g., rock mass, hydrologic), and conditions (disturbed or undisturbed) in order to compare the measured data with assumed or predicted behavior. It provides baseline information on parameters and processes that may be altered by site characterization, construction and operation activities. It monitors changes from the baseline condition of parameters that might affect repository performance.

Section 60.137 of 10 CFR 60 requires a Performance Confirmation Program that meets the requirements set forth in Subpart F. One of these requirements explicitly states that performance confirmation should start during site characterization and continued until permanent closure. The SCP should present a discussion on the Performance Confirmation Program and how the program intends to meet the requirements of Subpart F.

A comparison of the performance confirmation data with the original design bases and assumptions will be useful in determining the need for modifications to the design or in construction methods. These data will also help assess whether the performance of the natural and engineered features are within design limits. Performance confirmation data will help detect any substantial deviations from expected (or assumed) performance. The license amendment for permanent closure or a decision to retrieve will be greatly impacted by the results of the performance confirmation program.

The staff will review the SCP to determine if the plan considers those aspects of the performance confirmation plan that need to be implemented during site characterization. Discussions in the SCP for the performance confirmation program during site characterization should be considerably more detailed than those for the program during construction and operation. Relationships between these two phases of performance confirmation should be addressed.

4.2.4.11.2 Criteria

Discussions in the SCP pertaining to Performance Confirmation should satisfy the following criteria which have been derived from requirements of Subpart F.

I. Confirmation Parameters

1. A plan to identify the performance confirmation parameters should be described. Assurance should be provided that appropriate type and number of performance confirmation parameters have been selected.

2. Parameters for which performance confirmation will be initiated during site characterization should be identified as such. Application of specific measurements should also be addressed.

3. Acceptable reasons should be provided as to why performance confirmation will not be initiated for the remaining parameters until repository construction begins. For instance, if tests involving heating of the rock are not envisioned during site characterization, it may be acceptable that temperature measurements or monitoring can be delayed until wastes are emplaced.

II. Goals During Site Characterization

Much of the data on which the repository design for licensing review is based will be obtained during site characterization.

1. All relevant preliminary data that can later be refined as a result of subsequent performance confirmation measurements should be obtained.

2. During exploratory shaft sinking, instrumentation needed for long-term performance confirmation should be installed to the extent practicable

3. Data to establish subsurface baseline conditions (prior to repository construction) should be collected.

4. Performance confirmation monitoring activities should not adversely affect the ability of the natural and engineered elements of the repository system to meet the performance objectives.

III. Goals During Construction and Operation

The discussion in the SCP for Performance Confirmation Program during construction and operation may be limited in scope and is not expected to be as exhaustive as that for the program during site characterization. However, sufficient information should be given on planning and strategy to demonstrate the intent and scope of performance confirmation during construction and operation.

1. Perturbation of the subsurface conditions as a result of construction and emplacement activities should be measured (or monitored) and evaluated against design assumptions.

2. Measurements of rock deformation, rock stresses and strains, rates of water inflow, pore pressure, changes in ground water flow conditions, and thermomechanical response should be made. Provisions should be made for appropriate design /construction changes if these measurements are significantly different from the anticipated response.

3. The thermomechanical response of the underground facility should be monitored until permanent closure.

4. Backfill performance should be evaluated in-situ by conducting appropriate tests prior to emplacing permanent backfill.

5. The condition of representative waste packages should be monitored in an environment that is representative of the emplacement environment. Waste package monitoring should continue until permanent closure.

IV. Instrumentation

1. To the extent practicable, instruments with proven reliability should be used.

2. Redundancy in the type of instrument to measure a given parameter should be provided.

3. Provisions should be made to inspect instruments that are emplaced in-situ.

4. Instruments should be calibrated for the entire range of temperature and humidity likely to be experienced over the period of performance confirmation unless the manufacturer's specifications for an instrument already cover that range.

5. Multiple monitoring locations should be provided to capture the uncertainty due to spatial variations.

4.2.4.11.3 Applicable Parts of 10 CFR 60

60.137

Subpart F

4.2.4.11.4 other documents

In-situ Testing GTP

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